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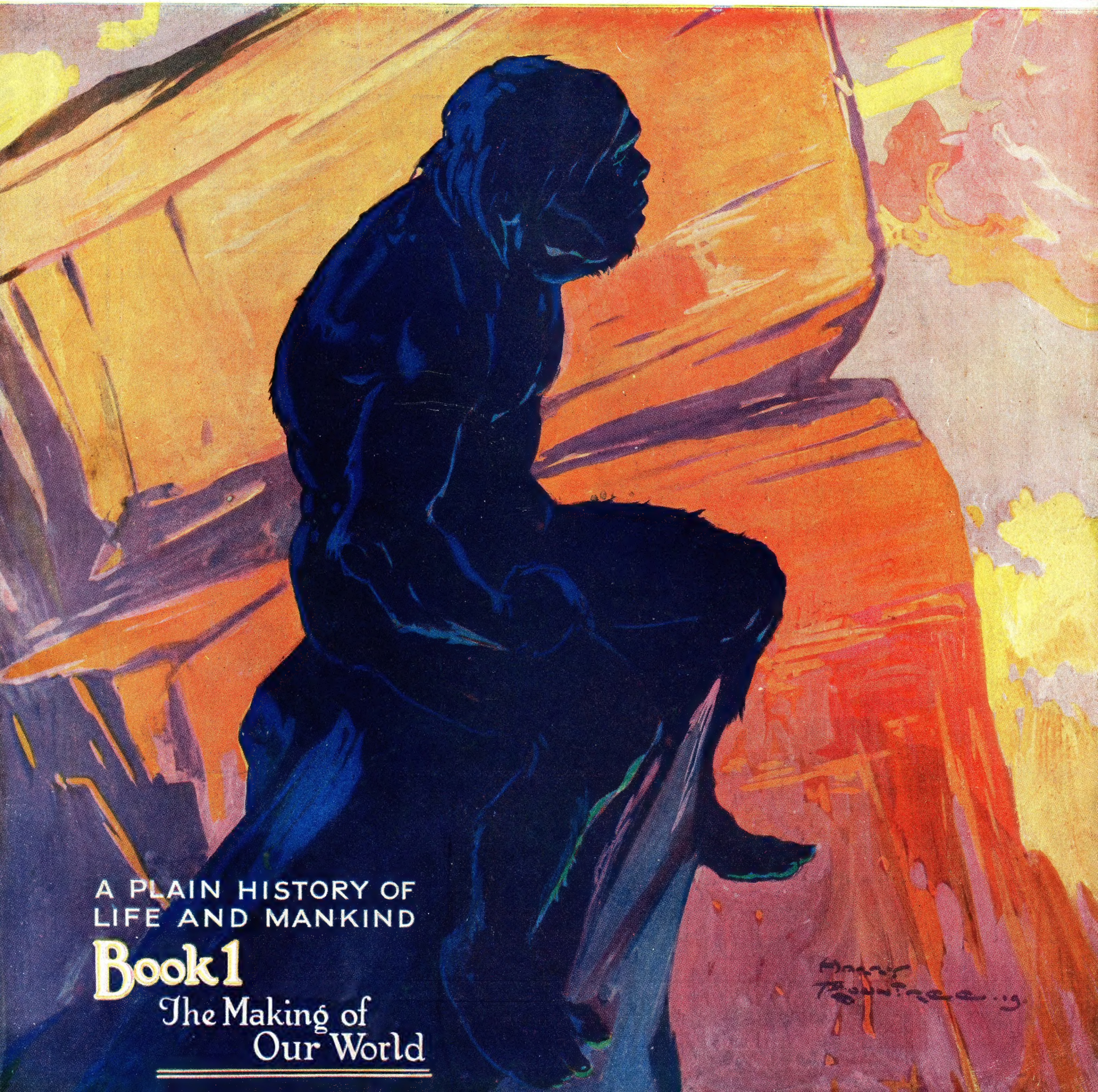
The OUTLINE of HISTORY

BY

H. G. WELLS.



A PLAIN HISTORY OF LIFE AND MANKIND

Book 1

The Making of Our World

THE OUTLINE OF HISTORY

BY H.G. WELLS

PART 2 PUBLISHED DEC. 5TH

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TWO PTERODACTYLS TOGETHER WITH TOOTHED SEA-BIRDS

[Frontispiece

THE OUTLINE OF HISTORY

BEING A PLAIN HISTORY OF LIFE AND MANKIND

BY H. G. WELLS

Written with the advice and : editorial help of :
MR ERNEST BARKER
SIR H. H. JOHNSTON
SIR E. RAY LANKESTER
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THE OUTLINE OF HISTORY

INTRODUCTION

"A philosophy of the history of the human race, worthy of its name, must begin with the heavens and descend to the earth, must be charged with the conviction that all existence is one—a single conception sustained from beginning to end upon one identical law."—FRIEDRICH RATZEL.

THIS *Outline of History* is an attempt to tell, truly and clearly, in one continuous narrative, the whole story of life and mankind so far as it is known to-day. It is written plainly for the general reader, but its aim goes beyond its use as merely interesting reading matter. There is a feeling abroad that the teaching of history considered as a part of general education is in an unsatisfactory condition, and particularly that the ordinary treatment of this "subject" by the class and teacher and examiner is too partial and narrow. But the desire to extend the general range of historical ideas is confronted by the argument that the available time for instruction is already consumed by that partial and narrow treatment, and that therefore, however desirable this extension of range may be, it is in practice impossible. If an Englishman, for example, has found the history of England quite enough for his powers of assimilation, then it seems hopeless to expect his sons and daughters to master universal history, if that is to consist of the history of England, plus the history of France, plus the history of Germany, plus the history of Russia, and so on. To which the only possible answer is that universal history is at once something more and something less than the aggregate of the national histories to which we are accustomed, that it must be approached in a different spirit and dealt with in a different manner. This book seeks to justify that answer. It has been written primarily to show that *history as one whole* is amenable to a more broad and comprehensive handling than is the history of special nations and periods, a broader handling that will bring it within the normal limitations of time and energy set to the reading and education of an ordinary citizen. This outline deals with ages and races and nations, where the ordinary history deals with reigns and pedigrees and campaigns; but it will not be found to be more crowded with names and dates nor more difficult to follow and understand. History is no exception amongst the sciences; as the gaps fill in, the outline simplifies; as the outlook broadens, the clustering multitude of details dissolves into general laws. And many topics of quite primary interest to mankind, the first appearance and the growth of scientific knowledge for example, and its effects upon human life, the elaboration of the ideas of money and credit, or the story of the origins and spread and influence of Christianity, which must be treated fragmentarily or by elaborate digressions in any partial history,

arise and flow completely and naturally in one general record of the world in which we live.

The need for a common knowledge of the general facts of human history throughout the world has become very evident during the tragic happenings of the last few years. Swifter means of communication have brought all men very close to one another for good or for evil. War becomes a universal disaster, blind and monstrously destructive; it bombs the baby in its cradle and sinks the food-ships that cater for the non-combatant and the neutral. There can be no peace now, we realize, but a common peace in all the world; no prosperity but a general prosperity. But *there can be no common peace and prosperity without common historical ideas.* Without such ideas to hold them together in harmonious co-operation, with nothing but narrow, selfish, and conflicting nationalist traditions, races and peoples are bound to drift towards conflict and destruction. This truth, which was apparent to that great philosopher Kant a century or more ago—it is the gist of his tract upon universal peace—is now plain to the man in the street. Our internal policies and our economic and social ideas are profoundly vitiated at present by wrong and fantastic ideas of the origin and historical relationship of social classes. A sense of history as the common adventure of all mankind is as necessary for peace within as it is for peace between the nations.

Such are the views of history that this *Outline* seeks to realize. It is an attempt to tell how our present state of affairs, this distressed and multifarious human life about us, arose in the course of vast ages and out of the inanimate clash of matter, and to estimate the quality and amount and range of the hopes with which it now faces its destiny. It is one experimental contribution to a great and urgently necessary educational reformation, which must ultimately restore universal history, revised, corrected, and brought up to date, to its proper place and use as the backbone of a general education. We say " restore," because all the great cultures of the world hitherto, Judaism and Christianity in the Bible, Islam in the Koran, have used some sort of cosmogony and world history as a basis. It may indeed be argued that without such a basis any true binding culture of men is inconceivable. Without it we are a chaos.[1]

Remarkably few sketches of universal history by one single author have been written. One book that has influenced the writer very strongly is Winwood Reade's *Martyrdom of Man.* This *dates,* as people say, nowadays, and it has a fine gloom of its own, but it is still an extraordinarily inspiring presentation of human history as one consistent process. Mr. F. S. Marvin's *Living Past* is also an admirable summary of human progress. America has recently produced two well-illustrated and up-to-date class books, Breasted's *Ancient Times* and Robinson's *Medieval and Modern Times,* which together give a very good idea of the story of mankind since the beginning of human societies. There are, moreover, quite a number of nominally Universal Histories in existence, but they are really not histories at all, they are encyclopedias of history; they lack the unity of presentation attainable only when the whole subject has been passed through one single mind. These universal histories are compilations, assemblies of separate national or regional histories by different hands, the parts being necessarily unequal in merit and authority and disproportionate one to another. Several such universal histories in thirty or forty volumes or so, adorned with allegorical title pages and illustrated by folding maps and plans of Noah's Ark, Solomon's Temple, and the Tower of Babel, were produced for the libraries of gentlemen in the eighteenth century. Helmolt's *World History,* in eight massive volumes, is a modern compilation of the same sort, very useful for reference and richly illustrated, but far better in its parts than as a whole. *The Encyclopedia Britannica* contains, of course, a complete encyclopedia of history within

[1] See upon this an excellent pamphlet by F. J. Gould, *History, the Supreme Subject in the Instruction of the Young* (Watts & Co.).

itself, and is the most modern of all such collections. F. Ratzel's *History of Mankind*, in spite of the promise of its title, is mainly a natural history of man, though it is rich with suggestions upon the nature and development of civilization. That publication and Miss Ellen Churchill Semple's *Influence of Geographical Environment*, based on Ratzel's work, are quoted in this *Outline*, and have had considerable influence upon its plan. F. Ratzel would indeed have been the ideal author for such a book as our present one. Unfortunately neither he nor any other ideal author was available.

The writer will offer no apology for making this experiment. His disqualifications are manifest. But such work needs to be done by as many people as possible, he was free to make his contribution, and he was greatly attracted by the task. He has read sedulously and made the utmost use of all the help he could obtain. There is not a chapter that has not been examined by some more competent person than himself and very carefully revised. He has particularly to thank his friends Sir E. Ray Lankester, Sir H. H. Johnston, Professor Gilbert Murray, and Mr. Ernest Barker for much counsel and direction and editorial help. Sir Richard Gregory, Professor J. L. Myres, Professor W. S. Culbertson of Harvard, Dr. Singer of Oxford, Mr. Philip Guedalla, Mr. L. Cranmer Byng, and Sir Denison Ross have all to be thanked for help, either by reading parts of the MS. or by answering questions and giving advice. But of course none of these generous helpers are to be held responsible for the judgements, tone, arrangement, or writing of this *Outline*. In the relative importance of the parts, in the moral and political implications of the story, the final decision has necessarily fallen to the writer. The problem of illustrations was a very difficult one for him, for he had had no previous experience in the production of an illustrated book. In Mr. J. F. Horrabin he has had the good fortune to find not only an illustrator but a collaborator. Mr. Horrabin has spared no pains to make his work informative and exact. His maps and drawings are a part of the text, the most vital and decorative part. Some of them, the hypothetical maps, for example, of the western world at the end of the last glacial age, during the "pluvial age" and 12,000 years ago, represent the reading and inquiry of many laborious days.

And here the writer owes a word of thanks to that living index of printed books, Mr. J. F. Cox of the London Library. He would also like to acknowledge here the help he has received from Mrs. Wells. Without her labour in typing and re-typing the drafts of the various chapters as they have been revised and amended, in checking references, finding suitable quotations, hunting up illustrations, and keeping in order the whole mass of material for this history, and without her constant help and watchful criticism, its completion would have been impossible.

H. G. WELLS.

Book I
THE MAKING OF OUR WORLD

I
THE EARTH IN SPACE AND TIME

THE earth on which we live is a spinning globe. Vast though it seems to us, it is a mere speck of matter in the greater vastness of space.

Space is, for the most part, emptiness. At great intervals there are in this emptiness flaring centres of heat and light, the "fixed stars." They are all moving about in space, notwithstanding that they are called fixed stars, but for a long time men did not realize their motion. They are so vast and at such tremendous distances that their motion is not perceived. Only in the course of many thousands of years is it appreciable. These fixed stars are so far off that, for all their immensity, they seem to be, even when we look at them through the most powerful telescopes, mere points of light, brighter or less bright. A few, however, when we turn a telescope upon them, are seen to be whirls and clouds of shining vapour which we call nebulæ. They are so far off that a movement of millions of miles would be imperceptible.

One star, however, is so near to us that it is like a great ball of flame. This one is the sun. The sun is itself in its nature like a fixed star, but it differs from the other fixed stars in appearance because it is beyond comparison nearer than they are; and because it is nearer men have been able to learn something of its nature. Its mean distance from the earth is ninety-three million miles. It is a mass of flaming matter, having a diameter of 866,000 miles. Its bulk is a million and a quarter times the bulk of our earth.

These are difficult figures for the imagination. If a bullet fired from a Maxim gun at the sun kept its muzzle velocity unimpaired, it would take seven years to reach the sun. And yet we say the sun is near, measured by the scale of the stars. If the earth were a small ball, one inch in diameter, the sun would be a globe of nine feet diameter; it would fill a small bedroom. It is spinning round on its axis, but since it is an incandescent fluid, its polar regions do not travel with the same velocity as its equator, the surface of which rotates in about twenty-five days. The surface visible to us consists of clouds of incandescent metallic vapour. At what lies below we can only guess. So hot is the sun's atmosphere that iron, nickel, copper, and tin are present in it in a gaseous state. About it at great distances circle not only our earth, but certain kindred bodies called the planets. These shine in the sky because they reflect the light of the sun; they are near enough for us to note their movements quite easily. Night by night their positions change with regard to the fixed stars.

It is well to understand how empty space is. If, as we have said, the sun were a ball nine feet across, our earth would, in proportion, be the size of a one-inch ball, and at a distance of 330 yards from the sun. The moon would be a speck the size of a small pea, twenty inches from the earth. Nearer to the sun than the earth would be two other very similar specks, the planets Mercury and Venus, at a distance of rather more than a hundred and two hundred yards respectively. Beyond the earth would come the planets Mars, Jupiter, Saturn, Uranus, and Neptune, at distances of 500, 850, 3,000, 6,300, and 10,000 yards respectively. There would also be a certain number of very much smaller specks, flying about amongst these planets, more particularly a number called the asteroids circling between Mars and Jupiter, and occasionally a little puff of more or less luminous vapour and dust would drift into the system from the almost limitless emptiness beyond. Such a puff is what we call a comet. *All the rest of the space about us and around us and for unfathomable distances beyond is cold, lifeless, and void.* The nearest fixed star to us, *on this minute scale,* be it remembered, of the earth as a one-inch ball, and the moon a little pea, would be over 40,000 miles away.

The science that tells of these things and how men have come to know about them is Astronomy, and to books of astronomy the reader must go to learn more about the sun and stars. The science and description of the world on which we live are called respectively Geology and Geography.

The diameter of our world is a little under 8,000 miles. Its surface is rough, the more projecting parts of the roughness are mountains, and in the hollows of its surface there is a film of water, the oceans and seas. This film of water is about five miles thick at its deepest part—that is to say, the deepest oceans have a depth of five miles. This is very little in comparison with the bulk of the world.

About this sphere is a thin covering of air, the atmosphere. As we ascend in a balloon or go up a mountain from the level of the seashore the air is continually less dense, until at last it becomes so thin that it cannot support life. At a height of twenty miles there is scarcely any air at all—not one hundredth part of the density of air at the surface of the sea. The highest point to which a bird can fly is about four miles up—the condor, it is said, can struggle up to that; but most small birds and insects which are carried up by aeroplanes or balloons drop off insensible at a much lower level, and the greatest height to which any mountaineer has ever climbed is under five miles. Men have flown in aeroplanes to a height of over four miles, and balloons with men in them have reached very nearly seven miles, but at the cost of considerable physical suffering. Small experimental balloons, containing not men, but recording instruments, have gone as high as twenty-two miles.

It is in the upper few hundred feet of the crust of the earth, in the sea, and in the lower levels of the air below four miles that life is found. We do not know of any life at all except in these films of air and water upon our planet. So far as we know, all the rest of space is as yet without life. Scientific men have discussed the possibility of life, or of some process of a similar kind, occurring upon such kindred bodies as the planets Venus and Mars. But they point merely to questionable possibilities.

Astronomers and geologists and those who study physics have been able to tell us something of the origin and history of the earth. They consider that, vast ages ago, the sun was a spinning, flaring mass of matter, not yet concentrated into a compact centre of heat and light, considerably larger than it is now, and spinning very much faster, and that as it whirled, a series of fragments detached themselves from it, which became the planets. Our earth is one of these planets. The flaring mass that was the material of the earth broke as it spun into two masses, a larger, the earth itself, and a smaller, which is now the dead, still moon. Astronomers give us convincing reasons for supposing that sun and earth and moon and all that system were then whirling about at a speed much greater than the speed at which they are moving to-day, and that at first our earth was a flaming thing upon which no life could live. The way in which they have reached these conclusions is by a very beautiful and interesting series of observations and reasoning, too long and elaborate for us to deal with here. But they oblige us to believe that the sun, incandescent though it is, is now much cooler than it was, and that it spins more slowly now than it did, and that it continues to cool and slow down. And they also show that the rate at which the earth spins is diminishing and continues to diminish—that is to say, that our day is growing longer and longer, and that the heat at the centre of the earth wastes slowly. There was a time when the day was not a half and not a third of what it is to-day; when a blazing hot sun, much greater than it is now, must have moved visibly—had there been an eye to mark it—from its rise to its setting across the skies. There will be a time when the day will be as long as a year is now, and the cooling sun, shorn of its beams, will hang motionless in the heavens.

It must have been in days of a much hotter sun, a far swifter day and night, high tides, great heat, tremendous storms and earthquakes, that life, of which we are a part, began upon the world. The moon also was nearer and brighter in those days and had a changing face.[1]

[1] For a convenient recent discussion of the origin of the earth and its early history before the seas were precipitated and sedimentation began, the student should consult Professor Burrell's contribution to the Yale lectures, *The Evolution of the Earth and its Inhabitants* (1918), edited by President Lull.

II
THE RECORD OF THE ROCKS

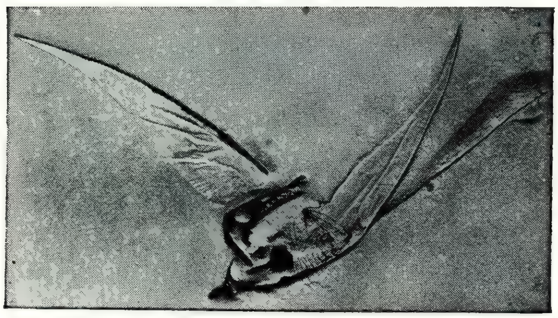
§ 1

WE do not know how life began upon the earth.[1]

Biologists, that is to say, students of life, have made guesses about these beginnings, but we will not discuss them here. Let us only note that they all agree that life began where the tides of those swift days spread and receded over the steaming beaches of mud and sand.

The First Living Things.

The atmosphere was much denser then, usually great cloud masses obscured the sun, frequent storms darkened the heavens. The land of those days, upheaved by violent volcanic forces, was a barren land, without vegetation, without soil. The almost incessant rain-storms swept down upon it, and rivers and torrents carried great loads of sediment out to sea, to become muds that hardened later into slates and shales, and sands that became sandstones. The geologists have studied the whole accumulation of these sediments as it remains to-day, from those of the earliest ages to the most recent. Of course the oldest deposits are the most distorted and changed and worn, and in them there is now no certain trace to be found of life at all. Probably the earliest forms of life were small and soft, leaving no evidence of their existence behind them. It was only when some of these living things developed skeletons and shells of lime and suchlike hard material that they left fossil vestiges after they died, and so put themselves on record for examination.



Natural History Museum Photograph.

AN EXCEPTIONALLY PLAIN PAGE IN THE RECORD OF THE ROCKS.

The remains of a Pterodactyl embedded in fine sandstone. The actual animal is shown in the large coloured illustration.

The literature of geology is very largely an account of the fossils that are found in the rocks, and of the order in which layers after layers of rocks follow one another. The very oldest rocks must have been formed before there was any sea at all, when the earth was too hot for a sea to exist, and when the water that is now sea was an atmosphere of steam mixed with the air. Its higher levels were dense with clouds, from which a hot rain fell towards the rocks below, to be converted again into steam long before it reached their incandescence. Below this steam atmosphere the molten world-stuff solidified as the first rocks. These first rocks must have solidified as a cake over glowing liquid material beneath, much as cooling lava does. They must have appeared first as crusts and clinkers. They must have been constantly remelted and recrystallized before any thickness of them became permanently solid. The name of Fundamental Gneiss is given to a great underlying system of crystalline rocks which probably formed age by age as this hot youth of the world drew to its close. The scenery of the world in the days when the Fundamental Gneiss was formed must have been more like the interior of a furnace than anything else to be found upon earth at the present time.

[1] But although we know nothing of the origin of life, there are many guesses, and some, in the light of modern physiological and chemical science, are quite plausible guesses. Here in this history of life we are doing our best to give only known and established facts in the broadest way, and to reduce the speculative element that must necessarily enter into our account to a minimum. The reader who is curious upon this question of life's beginning will find a very good summary of current suggestions done by Professor L. L. Woodruff in President Lull's excellent compilation *The Evolution of the Earth* (Yale University Press, 1918). Professor H. F. Osborne's *Origin and Evolution of Life* is also a very vigorous and suggestive book upon this subject, but it demands a fair knowledge of physics and chemistry in the reader.

After long ages the steam in the atmosphere began also to condense and fall right down to earth, pouring at last over these warm primordial rocks in rivulets of hot water and gathering in depressions as pools and lakes and the first seas. Into those seas the streams that poured over the rocks brought with them dust and particles to form a sediment, and this sediment accumulated in layers, or as geologists call them, *strata*, and formed the first Sedimentary Rocks. Those earliest sedimentary rocks sank into depressions and were covered by others; they were bent, tilted up, and torn by great volcanic disturbances and by tidal strains that swept through the rocky crust of the earth. We find these first sedimentary rocks still coming to the surface of the land here and there, either not covered by later strata or exposed after vast ages of concealment by the wearing off of the rock that covered them later—there are great surfaces of them in Canada especially; they are cleft and bent, partially remelted, recrystallized, hardened and compressed, but recognizable for what they are. And they contain no single certain trace of life at all. They are frequently called *Azoic* (lifeless) Rocks. But since in some of these earliest sedimentary rocks a substance called graphite (black lead) occurs, and also red and black oxide of iron, and since it is asserted that these substances need the activity of living things for their production, which may or may not be the case, some geologists prefer to call these earliest sedimentary rocks *Archæozoic* (primordial life). They suppose that the first life was soft living matter that had no shells or skeletons or any such structure that could remain as a recognizable fossil after its death, and that its chemical influence caused the deposition of graphite and iron oxide. This is pure guessing, of course, and there is at least an equal probability that in the time of formation of the Azoic Rocks, life had not yet begun.

Long ago there were found in certain of these ancient first-formed rocks in Canada, curious striped masses, and thin layers of white and green mineral substance which Sir William Dawson considered were fossil vestiges, the walls or coverings of some very simple sort of living thing which has now vanished from the earth. He called these markings *Eozoon Canadense* (the Canadian dawn-animal). There has been much discussion and controversy over this Eozoon, but to-day it is agreed that Eozoon is nothing more than a crystalline marking. Mixed minerals will often intercrystallize in blobs or branching shapes that are very suggestive of simple plant or animal forms. Any one who has made a lead tree in his schooldays,

Natural History Museum Photograph.

ANOTHER PLAIN ITEM IN THE RECORD OF THE ROCKS.

The thigh bone of a *Gigantosaurus*, one of the greatest dinosaurs. The lady holds a yard measure in her hand.

or lit those queer indoor fireworks known as serpents' eggs, which unfold like a long snake, or who has seen the curious markings often found in quartz crystals, or noted the tree-like pattern on old stone-ware beer mugs, will realize how closely non-living matter can sometimes mock the shapes of living things.

Overlying or overlapping these Azoic or Archæozoic rocks come others, manifestly also very ancient and worn, which do contain

traces of life. These first traces are of the very simplest description; they are the vestiges of simple plants called algæ, or traces like the tracks made by worms in the sea mud. There are also the skeletons of the microscopic creatures called Radiolaria. This second series of rocks is called the Proterozoic (beginning of life) series, and marks a long age in the world's history. Lying over and above the Proterozoic rocks is a third series, which is found to contain a considerable number and variety of traces of living things. First comes the evidence of a diversity of shell-fish, crabs, and such-like crawling things, worms, seaweeds, and the like; then of a multitude of fishes and of the beginnings of land plants and land creatures. These rocks are called the Palæozoic (ancient life) rocks. They mark a vast era, during which life was slowly spreading, increasing, and developing in the seas of our world. Through long ages, through the earliest Palæozoic time, it was no more than a proliferation of such swimming and creeping things in the water. There were creatures called trilobites; they were crawling things like big sea woodlice that were probably related to the American king-crab of to-day. There were also sea-scorpions, the prefects of that early world. The individuals of certain species of these were nine feet long. These were the very highest sorts of life. There were abundant different sorts of an order of shellfish called brachiopods. There were plant animals, rooted and joined together like plants, and loose weeds that waved in the waters.

It was not a display of life to excite our imaginations. There was nothing that ran or flew or even swam swiftly or skilfully. Except for the size of some of the creatures, it was not very different from, and rather less various than, the kind of life a student would gather from any summer-time ditch nowadays for microscopic examination. Such was the life of the shallow seas through a hundred million years or more in the early Palæozoic period. The land during that time was apparently absolutely barren. We find no trace nor hint of land life. Everything that lived in those days lived under water for most or all of its life.

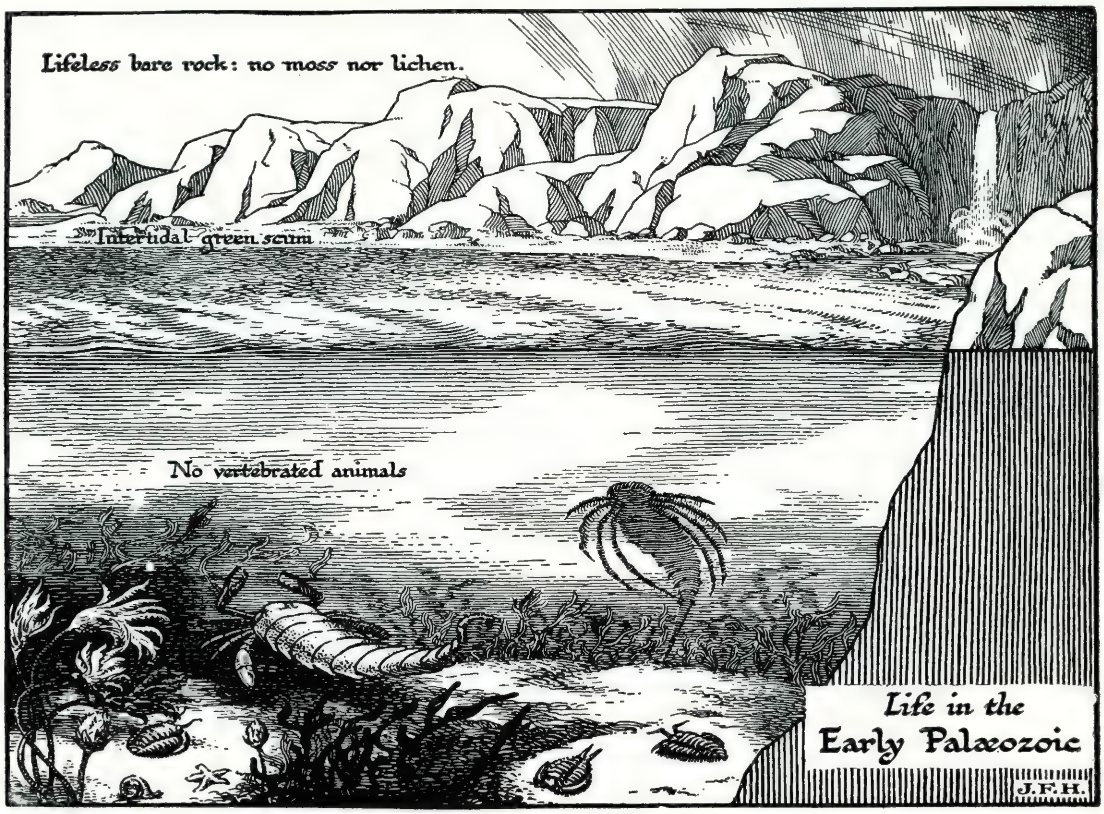


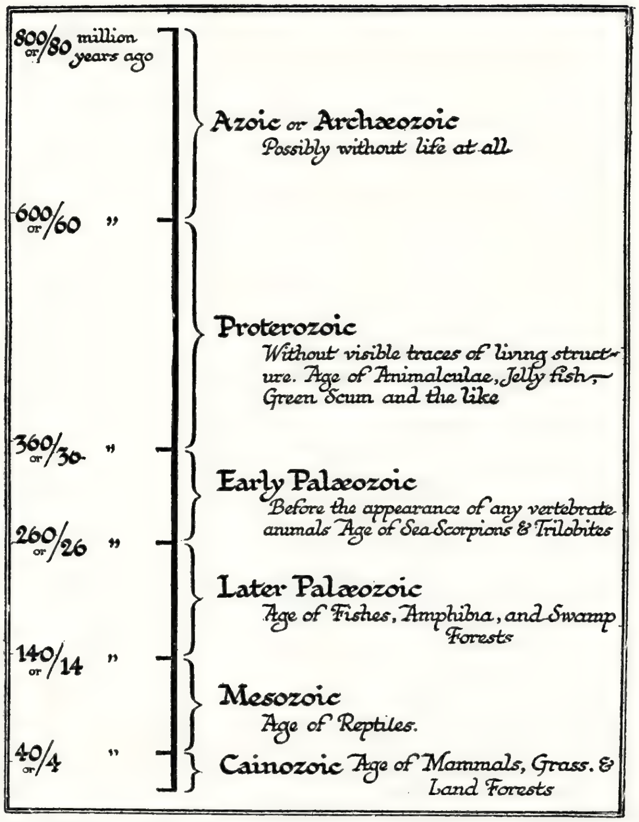
DIAGRAM OF LIFE IN THE EARLY PALÆOZOIC WORLD.

Between the formation of these Lower Palæozoic rocks in which the sea scorpion and trilobite ruled, and our own time, there have intervened almost immeasurable ages, represented by layers and masses of sedimentary rocks. There are first the Upper Palæozoic Rocks, and above these the geologists distinguish two great divisions. Next above the Palæozoic come the Mesozoic (middle life) rocks, a second vast system of fossil-bearing rocks, representing perhaps a hundred millions of swift years, and containing a wonderful array of fossil remains, bones of giant reptiles and the like, which we will presently describe; and above these again are the Cainozoic (recent life) rocks, a third great volume in the history of life, an unfinished volume of which the sand and mud that was carried out to sea yesterday by the rivers of the world, to bury the bones and scales and bodies and tracks that will become at last fossils of the things of to-day, constitute the last written leaf.

RESTORATION OF EARLY PALÆOZOIC LIFE.
Note its general resemblance, except for size, to the microscopic summer ditchwater life of to-day.

(It is, we may note, the practice of many geologists to make a break between the rest of the Cainozoic system of rocks and those which contain traces of humanity, which latter are cut off as a separate system under the name of Quaternary. But that, as we shall see, is rather like taking the last page of a book, which is really the conclusion of the last chapter, and making a separate chapter of it and calling it the last chapter.)

These markings and fossils in the rocks and the rocks themselves are our first historical documents. The history of life that men have puzzled out, and are still puzzling out from them is called the Record of the Rocks. By studying this record men are slowly piecing together a story of life's beginnings, and of the beginnings of our kind, of which our ancestors a century or so ago had no suspicion. But when we call these rocks and the fossils a record and a history, it must not be supposed that there



THIS IS A NOTEWORTHY DIAGRAM.

It gives the extreme estimates of the age of our earth and the proportionate length of the main divisions of its history. So vast is the time this line represents that even on the lowest estimate the whole duration of recorded history from earliest Egypt to our own day would be but an almost imperceptible scrap of the last division. Note the vast slowness with which life has developed. Note, too, that for more than half of the world's age there are no certain evidences of life at all.

is any sign of an orderly keeping of a record. It is merely that whatever happens leaves some trace, if only we are intelligent enough to detect the meaning of that trace. Nor are the rocks of the world in orderly layers one above the other, convenient for men to read. They are not like the books and pages of a library. They are torn, disrupted, interrupted, flung about, defaced, like a carelessly arranged office after it has experienced in succession a bombardment, a hostile military occupation, looting, an earthquake, riots, and a fire. And so it is that for countless generations this Record of the Rocks lay unsuspected beneath the feet of men. Fossils were discussed at Alexandria by Eratosthenes and others in the third century B.C., a discussion which is summarised in Strabo's *Geography* (? 20–10 B.C.). They were known to the Latin poet Ovid, but he did not understand their nature. He thought they were the first rude efforts of creative power. They were noted by Arabic writers in the tenth century. Leonardo da Vinci, who lived so recently as the opening of the sixteenth century (1452—1519), was one of the first Europeans to grasp the real significance of fossils,[1] and it has been only within the last century and a half that man has begun the serious and sustained deciphering of these long-neglected early pages of his world's history.

§ 2

How Old is the World?

Speculations about geological time vary enormously. Estimates of the age of the oldest rocks by geologists and astronomers starting from different standpoints have varied between 1,600,000,000, and 25,000,000. The lowest estimate was made by Lord Kelvin in 1867. Professor Huxley guessed at 400,000,000 years. There is a summary of views and the grounds upon which the estimates have been made in Osborne's *Origin and Evolution of Life*; he inclines to the moderate total of 100,000,000. It must be clearly understood by the reader how sketchy and provisional all these time estimates are. They rest nearly always upon

[1] There is a discussion of fossils in the Holkham Hall Leonardo MS.

theoretical assumptions of the slenderest kind. That the period of time has been vast, that it is to be counted by scores and possibly by hundreds of millions of years, is the utmost that can be said with certainty in the matter. It is quite open to the reader to divide every number in the appended time diagram by ten or multiply it by two ; no one can gainsay him. Of the relative amount of time as between one age and another we have, however, stronger evidence; if the reader cuts down the 800,000,000 we have given here to 400,000,000, then he must reduce the 40,000,000 of the Cainozoic to 20,000,000. And be it noted that whatever the total sum may be, most geologists are in agreement that *half or more than half of the whole of geological time had passed before life had developed to the Later Palæozoic level.* The reader reading quickly through these opening chapters may be apt to think of them as a mere swift prelude of preparation to the apparently much longer history that follows, but in reality that subsequent history is longer only because it is more detailed and more interesting to us. It looms larger in perspective. For ages that stagger the imagination this earth spun hot and lifeless, and again for ages of equal vastness it held no life above the level of the animalculæ in a drop of ditch-water.

Not only is Space from the point of view of life and humanity empty, but Time is empty also. Life is like a little glow, scarcely kindled yet, in these void immensities.

III

NATURAL SELECTION AND THE CHANGES OF SPECIES

NOW here it will be well to put plainly certain general facts about this new thing, *life*, that was creeping in the shallow waters and intertidal muds of the early Palæozoic period, and which is perhaps confined to our planet alone in all the immensity of space.

Life differs from all things whatever that are without life in certain general aspects. There are the most wonderful differences among living things to-day, but all living things past and present agree in possessing *a certain power of growth*; all living things *take nourishment*, all living things *move about* as they feed and grow, though the movement may be no more than the spread of roots through the soil or of branches in the air. Moreover, living things reproduce; they give rise to other living things, either by growing and then dividing or by means of seeds or spores or eggs or other ways of producing young. *Reproduction* is a characteristic of life.

No living thing goes on living for ever. There seems to be *a limit of growth* for every kind of living thing. Among very small and simple living things, such as that microscopic blob of living matter the *Amœba*, an individual may grow and then divide completely into two new individuals, which again may divide in their turn. Many other microscopic creatures live actively for a time, grow, and then become quiet and inactive, enclose themselves in an outer covering and break up wholly into a number of still smaller things, spores, which are released and scattered and again grow into the likeness of their parent. Among more complex creatures the reproduction is not usually such simple division, though division does occur even in the case of many creatures big enough to be visible to the unassisted eye. But the rule with almost all larger beings is that the individual grows up to a certain limit of size. Then, before it becomes unwieldy, its growth declines and stops. As it reaches its full size it *matures*, it begins to produce young, which are either born alive or hatched from eggs. But all of its body does not produce young. Only a special part does that. After

the individual has lived and produced offspring for some time, it ages and dies. It does so by a sort of necessity. There is a practical limit to its life as well as to its growth. These things are as true of plants as they are of animals. And they are not true of things that do not live. Non-living things, such as crystals, grow, but they have no set limits of growth or size, they *do not move of their own accord* and there is *no stir within them.* Crystals once formed may last unchanged for millions of years. There is *no reproduction* for any non-living thing.

DIAGRAM OF LIFE IN THE LATER PALÆOZOIC AGE.

Life is creeping out of the water. An insect, like a dragon-fly, is shown. There were amphibia like gigantic newts and salamanders, and even primitive reptiles in these swamps, as the larger illustration shows.

This growth and dying and reproduction of living things leads to some very wonderful consequences. The young which a living thing produces are either directly, or after some intermediate stages and changes (such as the changes of a caterpillar and butterfly), like the parent living thing. But they are never exactly like it or like each other. There is always a slight difference, which we speak of as *individuality.* A thousand butterflies this year may produce two or three thousand next year; these latter will look to us almost exactly like their predecessors, but each one will have just that slight difference. It is hard for us to see individuality in butterflies because we do not observe them very closely, but it is easy for us to see it in men. All the men and women in the world now are descended from the men and women of A.D. 1800, but not one of us now is exactly the same as one of that vanished generation. And what is true of men and butterflies is true of every sort of living thing, of plants as of animals. Every species changes all its individualities in each generation. That is as true of all the minute creatures that swarmed and reproduced and died in the Archæozoic and Proterozoic seas, as it is of men to-day.

Every species of living things is continually dying and being born again, as a multitude of fresh individuals.

Consider, then, what must happen to a newborn generation of living things of any species. Some of the individuals will be stronger or sturdier or better suited to succeed in life in some way than the rest, many individuals will be weaker or less suited. In particular single cases any sort of luck or accident may occur, but *on the whole* the better equipped individuals

will live and grow up and reproduce themselves and the weaker will *as a rule* go under. The latter will be less able to get food, to fight their enemies and pull through. So that in each generation there is as it were a picking over of a species, a picking out of most of the weak or unsuitable and a preference for the strong and suitable. This process is called *Natural Selection* or the *Survival of the Fittest.*[1]

It follows, therefore, from the fact that living things grow and breed and die, that every species, so long as the conditions under which it lives remain the same, becomes more and more perfectly fitted to those conditions in every generation.

But now suppose those conditions change, then the sort of individual that used to succeed may now fail to succeed and a sort of individual that could not get on at all under the old conditions may now find its opportunity. These species will change, therefore, generation by generation; the old sort of individual that used to prosper and dominate will fail and die out and the new sort of individual will become the rule,—until the general character of the species changes.

Suppose, for example, there is some little furry whitey-brown animal living in a bitterly cold land which is usually under snow. Such individuals as have the thickest, whitest fur will be least hurt by the cold, less seen by their enemies, and less conspicuous as they seek their prey. The fur of this species will thicken and its whiteness increase with every generation, until there is no advantage in carrying any more fur.

Imagine now a change of climate that brings warmth into the land, sweeps away the snows, makes white creatures glaringly visible during the greater part of the year and thick fur an encumbrance. Then every individual with a touch of brown in its colouring and a thinner fur will find itself at an advantage, and very white and heavy fur will be a handicap. There will be a weeding out of the white in favour of the brown in each generation. If this change of climate come about too quickly, it may of course exterminate the species altogether; but if it come about gradually, the species, although it may have a hard time, may yet be able to change itself and adapt itself generation by generation. This change and adaptation is called the *Modification of Species.*

Perhaps this change of climate does not occur all over the lands inhabited by the species; maybe it occurs only on one side of some great arm of the sea or some great mountain range or such-like divide, and not on the other. A warm ocean current like the Gulf Stream may be deflected, and flow so as to warm one side of the barrier, leaving the other still cold. Then on the cold side this species will still be going on to its utmost possible furriness and whiteness and on the other side it will be modifying towards brownness and a thinner coat. At the same time there will probably be other changes going on; a difference in the paws perhaps, because one half of the species will be frequently scratching through snow for its food, while the other will be scampering over brown earth. Probably also the difference of climate will mean differences in the sort of food available, and that may produce differences in the teeth and the digestive organs. And there may be changes in the sweat and oil glands of the skin due to the changes in the fur, and these will affect the excretory organs and all the internal chemistry of the body. And so through all the structure of the creature. A time will come when the two separated varieties of this formerly single species will become so unlike each other as to be recognizably different species. Such a splitting up of a species in the course of generations into two or more species is called the *Differentiation of Species.*

And it should be clear to the reader that given these elemental facts of life, given growth and death and reproduction with individual variation in a world that changes, life *must* change in this way, modification and differentiation *must* occur, old species *must* disappear, and new ones appear. We have chosen for our instance here a familiar sort of animal, but what is true of furry beasts in snow and ice is true of all life, and equally true of the soft jellies and simple beginnings that flowed and crawled for hundreds of millions of years between the tidal levels and in the shallow, warm waters of the Proterozoic seas.

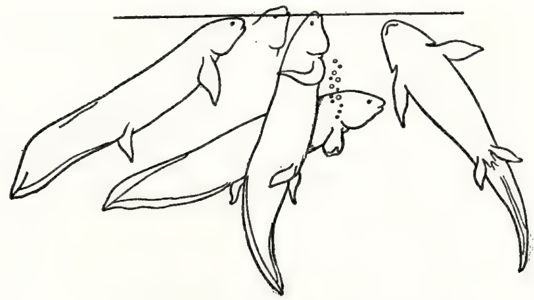
The early life of the early world, when the

[1] It might be called with more exactness the *Survival of the Fitter.*

ANIMAL LIFE OF THE LATER PALÆOZOIC.

blazing sun rose and set in only a quarter of the time it now takes, when the warm seas poured in great tides over the sandy and muddy shores of the rocky lands and the air was full of clouds and steam, must have been modified and varied and species must have developed at a great pace. Life was probably as swift and short as the days and years; the generations, which natural selection picked over, followed one another in rapid succession.

Natural selection is a slower process with man than with any other creature. It takes twenty years or more before an ordinary human being in Western Europe grows up and reproduces. In the case of most animals the new generation is on trial in a year or less. With such simple and lowly beings, however, as first appeared in the primordial seas, growth and reproduction was probably a matter of a few brief hours or even of a few brief minutes. Modification and differentiation of species must accordingly have been very rapid, and life had already developed a very great variety of widely contrasted forms before it began to leave traces in the rocks. The Record of the Rocks does not begin, therefore, with any group of closely related forms from which all subsequent and existing creatures are descended. It begins in the midst of the game, with nearly every main division of the animal kingdom already represented. Plants are already plants, and animals animals. The curtain rises on a drama in the sea that has already begun, and has been going on for some time. The brachiopods are discovered already in their shells, accepting and consuming much the same sort of food that



Australian Lung-fish breathing air. After Dean.

A TRANSITION TYPE BETWEEN WATER VERTEBRATA AND LAND VERTEBRATA.

oysters and mussels do now; the great water scorpions crawl among the seaweeds, the trilobites roll up into balls and unroll and scuttle away. In that ancient mud and among those early weeds there was probably as rich and abundant and active a life of infusoria and the like as one finds in a drop of ditch-water to-day. In the ocean waters too, down to the utmost downward limit to which light could filter, then as now, there was an abundance of minute and translucent, and in many cases phosphorescent, beings.

But though the ocean and intertidal waters already swarmed with life, the land above the high-tide line was still, so far as we can guess, a stony wilderness without a trace of life.

IV

THE INVASION OF THE DRY LAND BY LIFE

§ 1

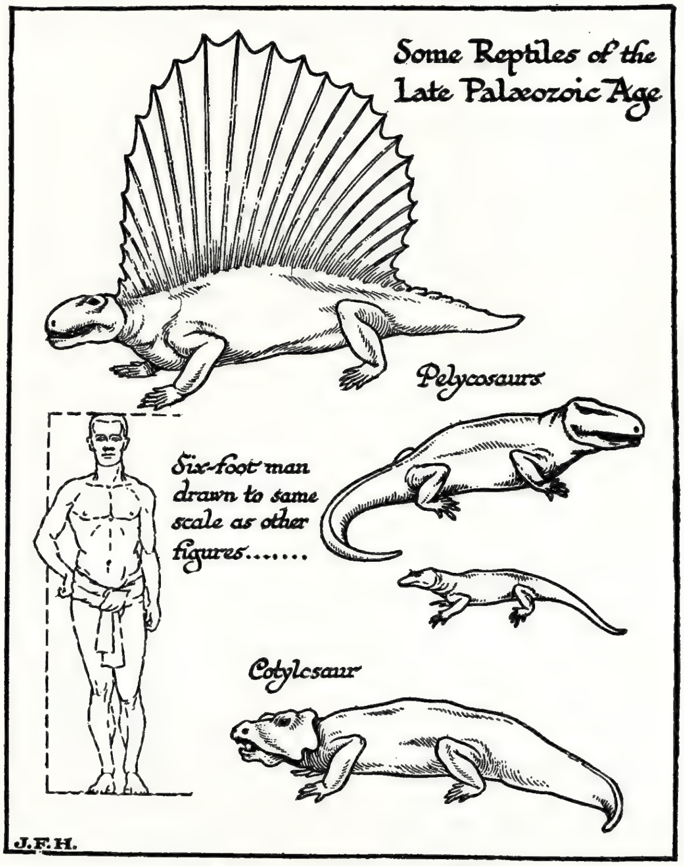
WHEREVER the shore line ran there was life, and that life went on in and by and with water as its home, its medium, and its fundamental necessity.

The first jelly-like beginnings of life must have perished whenever they got out of the water, as jelly-fish dry up and perish on our beaches to-day. Drying up was the fatal thing for life in those days, against which at first it had no protection.

Life and Water.

But in a world of rain-pools and shallow seas and tides, any variation that enabled a living thing to hold out and keep its moisture during hours of low tide or drought met with every encouragement in the circumstances of the time. There must have been a constant risk of stranding. And, on the other hand, life had to keep rather near the shore and beaches in the shallows because it had need of air (dissolved of course in the water) and light.

No creature can breathe, no creature can digest its food, without water. We talk of



SOME OF THE EARLIEST REPTILES.

breathing air, but what all living things really do is to breathe oxygen dissolved in water. The air we ourselves breathe must first be dissolved in the moisture in our lungs; and all our food must be liquefied before it can be assimilated. Water-living creatures which are always under water, wave the freely exposed gills by which they breathe in that water, and extract the air dissolved in it. But any creature that is to be exposed for any time out of the water, must have its body and its breathing apparatus protected from drying up. Before the seaweeds could creep up out of the Early Palæozoic seas into the intertidal line of the beach, they had to develop a tougher outer skin to hold their moisture. Before the ancestor of the sea scorpion could survive being left by the tide it had to develop its casing and armour. The trilobites probably developed their tough covering and rolled up into balls, far less as a protection against each other and any other enemies they may have possessed, than as a precaution against drying. And when presently, as we ascend the Palæozoic rocks, the fish appear, first of all the backboned or vertebrated animals, it is evident that a number of them are already adapted by the protection of their gills by gill covers and by a sort of primitive lung swimming-bladder, to face the same risk of temporary stranding.

Now the weeds and plants that were adapting themselves to intertidal conditions were also bringing themselves into a region of brighter light, and light is very necessary and precious to all plants. Any development of structure that would stiffen them and hold them up to the light, so that instead of crumpling and flopping when the waters receded, they would stand up outspread, was a great advantage. And so we find them developing fibre and support and the beginning of *woody fibre* in them. The early plants reproduced by soft spores, or half-animal "gametes," that were released in water, were distributed by water and could

PLESIOSAURS ON A MESOZOIC BEACH

only germinate under water. The early plants were tied, and most lowly plants to-day are tied, by the conditions of their life cycle, to water. But here again there was a great advantage to be got by the development of some protection of the spores from drought that would enable reproduction to occur without submergence. So soon as a species could do that, it could live and reproduce and spread above the high-water mark, bathed in light and out of reach of the beating and distress of the waves. The main classificatory divisions of the larger plants mark stages in the release of plant life from the necessity of submergence by the development of woody support and of a method of reproduction that is more and more defiant of drying up. The lower plants are still the prisoner attendants of water. The lower mosses must live in damp, and even the development of the spore of the ferns demands at certain stages extreme wetness. The highest plants have carried freedom from water so far that they can live and reproduce if only there is some moisture in the soil below them. They have solved their problem of living out of water altogether.

The essentials of that problem were worked out through the vast æons of the Proterozoic Age and the early Palæozoic Age by nature's method of experiment and trial. Then slowly, but in great abundance, a variety of new plants began to swarm away from the sea and over the lower lands, still keeping to swamp and lagoon and water-course as they spread.

§ 2

And after the plants came the animal life.

The Earliest Animals.

There is no sort of land animal in the world, as there is no sort of land plant, whose structure is not primarily that of a water-inhabiting being which has been adapted through the modification and differentiation of species to life out of the water. This adaptation is attained in various ways. In the case of the land scorpion the gill-plates of the primitive sea scorpion are sunken into the body so as to make the lung-books secure from rapid evaporation. The gills of crustaceans, such as the crabs which run about in the air, are protected by the gill-cover extensions of the back shell or carapace. The ancestors of the insects developed a system of air pouches and air tubes, the tracheal tubes, which carry the air all over the body before it is dissolved. In the case of the vertebrated land animals, the gills of the ancestral fish were first supplemented and then replaced by a bag-like growth from the throat, the primitive lung swimming-bladder. To this day there survive certain mudfish which enable us to understand very clearly the method by which the vertebrated land animals worked their way out of the water. These creatures (*e.g.* the African lung fish) are found in tropical regions in which there is a rainy full season and a dry season, during which the rivers become mere ditches of baked mud. During the rainy season these fish swim about and breathe by gills like any other fish. As the waters of the river evaporate, these fish bury themselves in the mud, their gills go out of action, and the creature keeps itself alive until the waters return by swallowing air, which passes into its swimming-bladder. The Australian lung fish, when it is caught by the drying up of the river in stagnant pools, and the water has become deaerated and foul, rises to the surface and gulps air. A newt in a pond does exactly the same thing. These creatures still remain at the transition stage, the stage at which the ancestors of the higher vertebrated animals were released from their restriction to an under-water life.

The amphibia (frogs, newts, tritons, etc.) still show in their life history all the stages in the process of this liberation. They are still dependent on water for their reproduction; their eggs must be laid in sunlit water, and there they must develop. The young tadpole has branching external gills that wave in the water; then a gill cover grows back over them and forms a gill chamber. Then, as the creature's legs appear and its tail is absorbed, it begins to use its lungs, and its gills dwindle and vanish. The adult frog can live all the rest of its days in the air, but it can be drowned if it is kept steadfastly below water. When we come to the reptile, however, we find an egg which is protected from evaporation by a tough egg case, and this egg produces young which breathe by lungs from the very moment of hatching. The reptile is on all fours with the

seeding plant in its freedom from the necessity to pass any stage of its life cycle in water.

The later Palæolithic Rocks of the northern hemisphere give us the materials for a series of pictures of this slow spreading of life over the land. Geographically, all round the northern half of the world it was an age of lagoons and shallow seas very favourable to this invasion. The new plants, now that they had acquired the power to live this new aerial life, developed with an extraordinary richness and variety.

There were as yet no flowering plants of any sort,[1] no grasses nor trees that shed their leaves in winter;[2] the first "flora" consisted of great tree ferns, gigantic equisetums, cycad ferns, and kindred vegetation. Many of these plants took the form of huge-stemmed trees, of which great multitudes of trunks survive fossilized to this day. Some of these trees were over a hundred feet high, of orders and classes now vanished from the world. They stood with their stems in the water, in which no doubt there was a thick tangle of soft mosses and green slime and fungoid growths that left few plain vestiges behind them. The abundant remains of these first swamp forests constitute the main coal measures of the world of to-day.

[1] Phanerogams. [2] Deciduous trees.

Amidst this luxuriant primitive vegetation crawled and glided and flew the first insects. They were rigid-winged, four-winged creatures, often very big, some of them having wings measuring a foot in length. There were numerous dragon flies—one found in the Belgian coal-measures had a wing span of twenty-nine inches! There were also a great variety of flying cockroaches. Scorpions abounded, and a number of early spiders, which, however, had no spinnerets for web making. Land snails appeared. So too did the first-known step of our own ancestry upon land, the amphibia. As we ascend the higher levels of the Later Palæozoic record, we find the process of air adaptation has gone as far as the appearance of true reptiles amidst the abundant and various amphibia.

The land life of the Upper Palæozoic Age was the life of a green swamp forest without flowers or birds or the noises of modern insects. There were no big land beasts at all; wallowing amphibia and primitive reptiles were the very highest creatures that life had so far produced. Whatever land lay away from the water or high above the water was still altogether barren and lifeless. But steadfastly, generation by generation, life was creeping away from the shallow sea-water of its beginning.

V

CHANGES IN THE WORLD'S CLIMATE

§ 1

THE Record of the Rocks is like a great book that has been carelessly misused. All its pages are torn, worn, and defaced, and many are altogether missing. The outline of the story that we sketch here has been pieced together slowly and painfully in an investigation that is still incomplete and still in progress. The Carboniferous Rocks, the "coal-measures," give us a vision of the first great expansion of life over the wet lowlands. Then come the torn pages known as the Permian Rocks (which count as the last of the palæozoic), that preserve very little for us of the land vestiges of their age. Only after a long interval of time does the history spread out generously again.

Why Life must change continually.

It must be borne in mind that great changes of climate have always been in progress, that have sometimes stimulated and sometimes checked life. Every species of living thing is always adapting itself more and more closely to its conditions. And conditions are always changing. There is no finality in adaptation. There is a continuing urgency towards fresh change.

About these changes of climate some explanations are necessary here. They are not regular changes; they are slow fluctuations between heat and cold. The reader must not think that because the sun and earth were once incan-

descent, the climatic history of the world is a simple story of cooling down. The centre of the earth is certainly very hot to this day, but we feel nothing of that internal heat at the surface; the internal heat, except for volcanoes and hot springs, has not been perceptible at the surface since first the rocks grew solid. Even in the Azoic or Archæozoic Age there are traces in ice-worn rocks and the like of periods of intense cold. Such cold waves have always been going on everywhere, alternately with warmer conditions. And there have been periods of great wetness and periods of great dryness throughout the earth.

A complete account of the causes of these great climatic fluctuations has still to be worked out, but we may perhaps point out some of the chief of them.[1] Prominent among them is the fact that the earth does not spin in a perfect circle round the sun. Its path or orbit is like a hoop that is distorted; it is, roughly speaking, elliptical (ovo-elliptical), and the sun is nearer to one end of the ellipse than the other. It is at a point which is a focus of the ellipse. And the shape of this orbit never remains the same. It is slowly distorted by the attractions of the other planets, for ages it may be nearly circular, for ages it is more or less elliptical. As the ellipse becomes most nearly circular, then the focus becomes most nearly the centre. When the orbit becomes most elliptical, then the position of the sun becomes most remote from the middle or, to use the astronomer's phrase, most eccentric. When the orbit is most nearly circular, then it must be manifest that all the year round the earth must be getting much the same amount of heat from the sun; when the orbit is most distorted, then there will be a season in each year when the earth is nearest the sun (this phase is called *Perihelion*) and getting a great deal of heat comparatively, and a season when it will be at its furthest from the sun (*Aphelion*) and getting very little warmth. A planet at *aphelion* is travelling its slowest, and its fastest at *perihelion*; so that the hot

[1] See Sir R. Ball's *Causes of the Great Ice Age*, and Dr. Croll's *Climate and Time*. These are sound books to read still, but the reader will find many of their conclusions modified in Wright's *The Quaternary Ice Age*, which is a quarter of a century more recent.

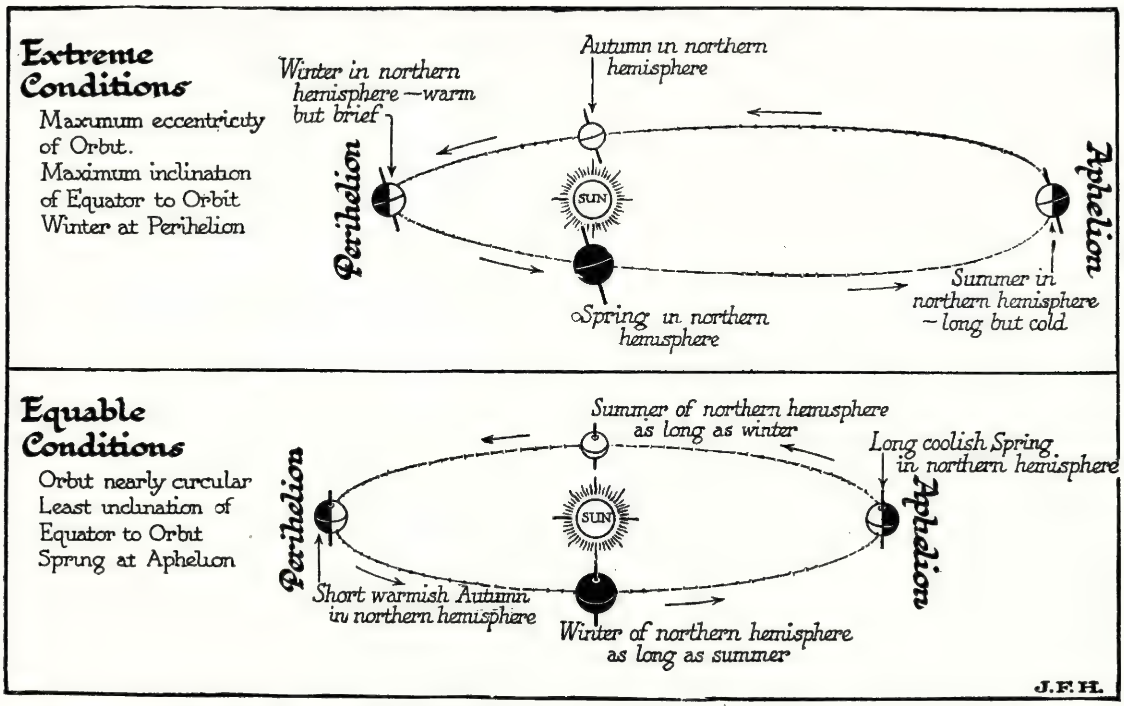


DIAGRAM TO ILLUSTRATE ONE SET OF CAUSES, THE ASTRONOMICAL VARIATIONS, WHICH MAKE THE CLIMATE OF THE WORLD CHANGE SLOWLY BUT CONTINUOUSLY.

It does not change in regular periods. It fluctuates irregularly through vast ages. As the world climate changes, life must change too or perish.

part of its year will last for a much less time than the cold part of its year. (Sir Robert Ball calculated that the greatest difference possible between the seasons was thirty-three days.) During ages when the orbit is most nearly circular there will therefore be least extremes of climate, and when the orbit is at its greatest eccentricity, there will be an age of cold with great extremes of seasonal temperature. These *changes in the orbit of the earth* are due to the varying pull of all the planets, and Sir Robert Ball declared himself unable to calculate any regular cycle of orbital change, but Professor G. H. Darwin maintained that it is possible to make out a kind of cycle between greatest and least eccentricity of about 200,000 years.

But this change in the shape of the orbit is only one cause of the change of the world's climate. There are many others that have to be considered with it. As most people know, the change in the seasons is due to the fact that the equator of the earth is inclined at an angle to the plane of its orbit. If the earth stood up straight in its orbit, so that its equator was in the plane of its orbit, there would be no change in the seasons at all. The sun would always be overhead at the equator, and the day and night would each be exactly twelve hours long throughout the year everywhere. It is this inclination which causes the difference in the seasons and the unequal length of the day in summer and winter. There is, according to Laplace, a possible variation of three degrees (from 22° 6′ to 24° 50′) in this inclination of the equator to the orbit, and when this is at a maximum, the difference between summer and winter is at its greatest. Great importance has been attached to this variation in the inclination of the equator to the orbit by Dr. Croll in his book *Climate and Time*. At present the angle is 23° 27′. Manifestly when the angle is at its least, the world's climate, other things being equal, will be most equable.

And as a third important factor there is what is called the *precession of the equinoxes*. This is a slow wabble of the pole of the spinning earth that takes 25,000 odd years. Any one who watches a spinning top as it "sleeps," will see its axis making a slow circular movement, exactly after the fashion of this circling movement of the earth's axis. The north pole, therefore, does not always point to the same north point among the stars; its pointing traces out a circle in the heavens every 25,000 years.

Now, there will be times when the earth is at its extreme of aphelion or of perihelion, when one hemisphere will be most turned to the sun in its midsummer position and the other most turned away at its midwinter position. And as the precession of the equinoxes goes on, a time will come when the summer-winter position will come not at aphelion and perihelion, but at the half-way points between them. When the summer of one hemisphere happens at perihelion and the winter at aphelion, it will be clear that the summer of the other hemisphere will happen at aphelion and its winter at perihelion. One hemisphere will have a short hot summer and a very cold winter, and the other a long cold summer and a briefer warmish winter. But when the summer-winter positions come at the half-way point of the orbit, and it is the spring of one hemisphere and the autumn of the other that is at aphelion or perihelion, there will not be the same wide difference between the climate of the two hemispheres.

Here are three wavering systems of change all going on independently of each other; the precession of the equinoxes, the change in the obliquity of the equator to the orbit, and the changes in the eccentricity of the orbit. Each system tends by itself to produce periods of equability and periods of greater climatic contrast. And all these systems of change interplay with each other. When it happens that at the same time the orbit is most nearly circular, the equator is at its least inclination from the plane of the earth's orbit, and the spring and autumn are at perihelion and aphelion, then all these causes will be conspiring to make climate warm and uniform; there will be least difference of summer and winter. When, on the other hand, the orbit is in its most eccentric stage of deformation, when also the equator is most tilted up and when further the summer and winter are at aphelion and perihelion, then climates will be at their extremest and winter at its bitterest. There will be great accumulations of ice and snow in

winter; the heat of the brief hot summer will be partly reflected back into space by the white snow, and it will be unequal to the task of melting all the winter's ice before the earth spins away once more towards its chilly aphelion. The earth will accumulate cold so long as this conspiracy of extreme conditions continues.

So our earth's climate changes and wavers perpetually as these three systems of influence come together with a common tendency towards warmth or severity, or as they contradict and cancel each other.

We can trace in the Record of the Rocks an irregular series of changes due to the interplay of these influences; there have been great ages when the separate rhythms of these three systems kept them out of agreement and the atmosphere was temperate, ages of world-wide warmth, and other ages when they seemed to concentrate bitterly to their utmost extremity, to freeze out and inflict the utmost stresses and hardship upon life.

And in accordance we find from the record in the rocks that there have been long periods of expansion and multiplication when life flowed and abounded and varied, and harsh ages when there was a great weeding out and disappearance of species, genera, and classes, and the learning of stern lessons by all that survived. Such a propitious conjunction it must have been that gave the age of luxuriant low-grade growth of the coal measures; such an adverse series of circumstances that chilled the closing æons of the Palæolithic time.

It is probable that the warm spells have been long relatively to the cold ages. Our world to-day seems to be emerging with fluctuations from a prolonged phase of adversity and extreme conditions. Half a million years ahead it may be a winterless world with trees and vegetation even in the polar circles. At present we have no certainty in such a forecast, but later on, as knowledge increases, it may be possible to reckon with more precision, so that our race will make its plans thousands of years ahead to meet the coming changes.

§ 2

Another entirely different cause of changes in the general climate of the earth may be due to variations in the heat of the sun. We do not yet understand what causes the heat of the sun or what sustains that undying fire. It is possible that in the past there have been periods of greater and lesser intensity. About that we know nothing; human experience has been too short; and so far we have been able to find no evidence on this matter in the geological record. On the whole, scientific men are inclined to believe that the sun has blazed with a general steadfastness throughout geological time. It may have been cooling slowly, but, speaking upon the scale of things astronomical, it has certainly not cooled very much.

The Sun a Steadfast Star.

§ 3

A third great group of causes influencing climate are to be found in the forces within the world itself. Throughout the long history of the earth there has been a continuous wearing down of the hills and mountains by frost and rain and a carrying out of their material to become sedimentary rocks under the seas. There has been a continuous process of wearing down the land and filling up the seas, by which the seas, as they became shallower, must have spread more and more over the land. The reverse process, a process of crumpling and upheaval, has also been in progress, but less regularly. The forces of upheaval have been spasmodic; the forces of wearing down continuous. For long ages there has been comparatively little volcanic upheaval, and then have come periods in which vast mountain chains have been thrust up and the whole outline of land and sea changed. Such a time was the opening stage of the Cainozoic period, in which the Alps, the Himalayas, and the Andes were all thrust up from the sea-level to far beyond their present elevations, and the main outlines of the existing geography of the world were drawn.

Changes from within the Earth.

Now, a time of high mountains and deep seas would mean a larger dry land surface for the world, and a more restricted sea surface, and a time of low lands would mean a time of wider and shallower seas. High mountains precipitate moisture from the atmosphere and hold it out of circulation as snow and glaciers, while

Natural History Museum Photograph.

THE BONES OF A VERY INTERESTING EARLY MESOZOIC REPTILE, *PAREIOSAURUS.*

It belonged to a group, the Theriomorphous reptiles, whose skeletons show many features that also distinguish mammalian skeletons. The mammals, including ourselves, must be descended from very similar reptilian creatures.

smaller oceans mean a lesser area for surface evaporation. Other things being equal, lowland stages of the world's history would be ages of more general atmospheric moisture than periods of relatively greater height of the mountains and greater depth of the seas. But even small increases in the amount of moisture in the air have a powerful influence upon the transmission of radiant heat through that air. The sun's heat will pass much more freely through dry air than through moist air, and so a greater amount of heat would reach the land surfaces of the globe under the conditions of extremes of elevation and depth, than during the periods of relative lowness and shallowness. Dry phases in the history of the earth mean, therefore, hot days. But they also mean cold nights, because for the same reason that the heat comes abundantly to the earth, it will be abundantly radiated away. Moist phases mean, on the other hand, cooler days and warmer nights. The same principle applies to the seasons, and so a phase of great elevations and depressions of the surface would also be another contributory factor on the side of extreme climatic conditions.

And a stage of greater elevation and depression would intensify its extreme conditions by the gradual accumulation of ice caps upon the polar regions and upon the more elevated mountain masses. This accumulation would be at the expense of the sea, whose surface would thus be further shrunken in comparison with the land.

Here then is another set of varying influences that will play in with and help or check the influence of the astronomical variations stated in §1 and §2. There are other more localized forces at work into which we cannot go in any detail here, but which will be familiar to the student of the elements of physical geography; the influence of great ocean currents in carrying warmth from equatorial to more temperate latitudes; the interference of mountain chains with the moisture borne by prevalent winds and the like. As in the slow processes of nature these currents are deflected or the mountain chains worn down or displaced by fresh upheavals, the climate over great areas will be changed and all the conditions of life changed with it. Under the incessant slow variations of these astronomical, telluric, and geographical influences life has no rest. As its conditions change it must change or perish.

§ 4

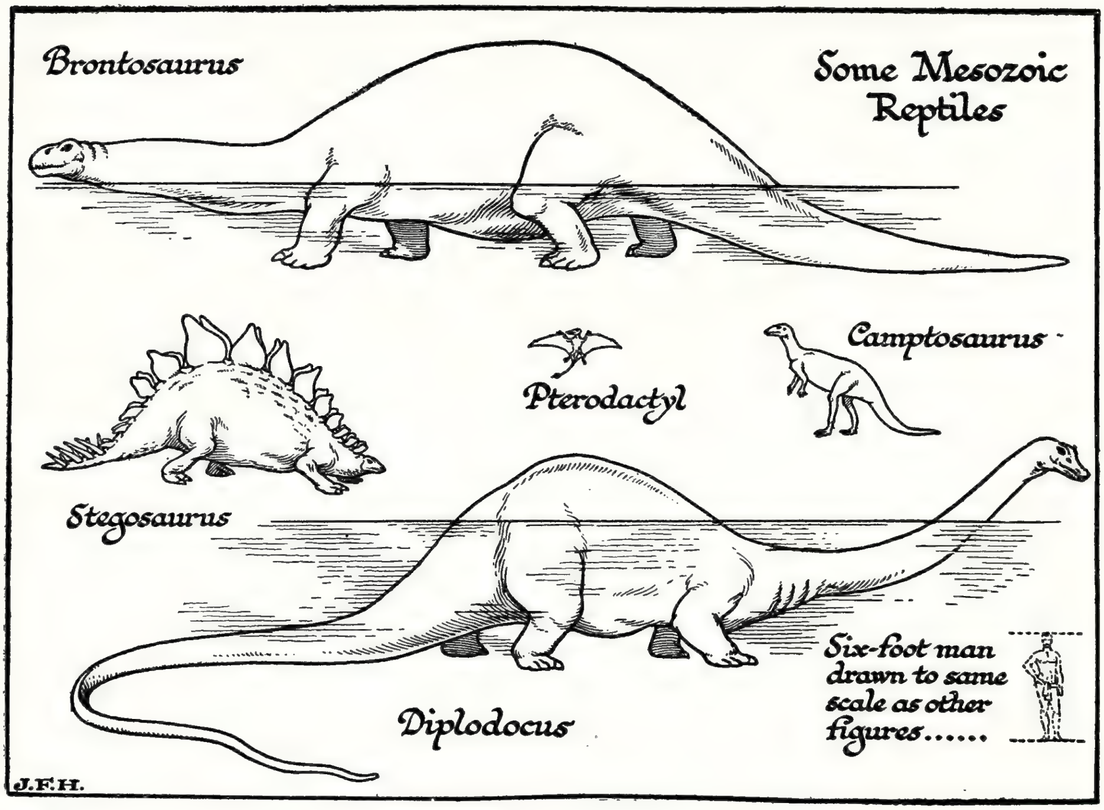
Life may control Change.

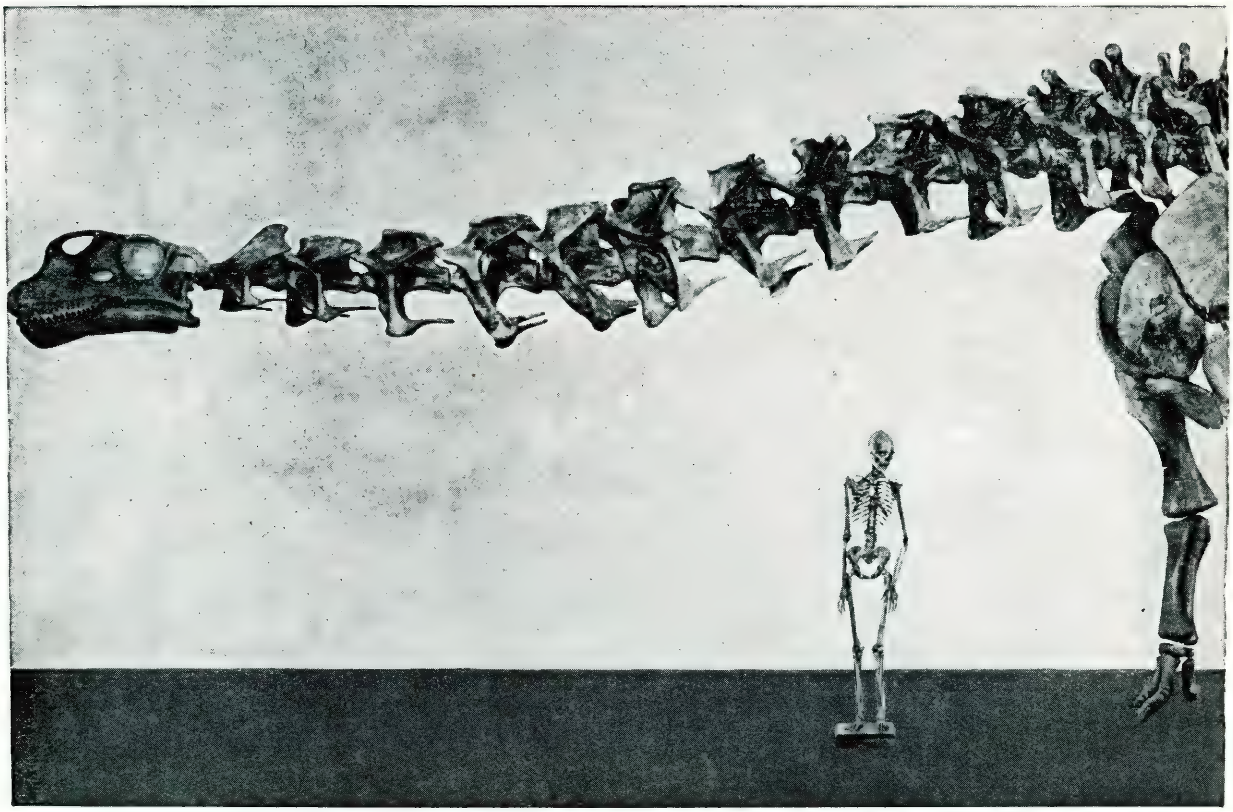
And while we are enumerating the forces that change climate and the conditions of terrestrial life, we may perhaps look ahead a little and add a fourth set of influences, at first unimportant in the history of the world so far as the land surface is concerned, but becoming more important

after the age of Reptiles, to which we shall proceed in our next chapter. These are the effects produced upon climate by life itself. Particularly great is the influence of vegetation, and especially that of forests. Every tree is continually transpiring water vapour into the air; the amount of water evaporated in summer by a lake surface is far less than the amount evaporated by the same area of beech forest. As in the later Mesozoic and the Cainozoic Age, great forests spread over the world, and their action in keeping the air moist and mitigating and stabilizing climate by keeping the summer cool and the winter mild must have become more and more important. Moreover, forests accumulate and protect soil and so prepare the possibility of agricultural life.

Water-weeds again may accumulate to choke and deflect rivers, flood and convert great areas into marshes, and so lead to the destruction of forests or the replacement of grass-lands by boggy wildernesses.

Finally, with the appearance of human communities, came what is perhaps the most powerful of all living influences upon climate. By fire and plough and axe man alters his world. By destroying forests and by irrigation man has already affected the climate of great regions of the world's surface. The destruction of forests makes the seasons more extreme; this has happened, for instance, in the north-eastern states of the United States of America. Moreover, the soil is no longer protected from the scour of rain, and is washed away, leaving only barren rock beneath. This has happened in Spain and Dalmatia and, some thousands of years earlier, in South Arabia. By irrigation, on the other hand, man restores the desert to life and mitigates climate. This process is going on in North-west India and Australia. In the future, by making such operations world-wide and systematic, man may be able to control climate to an extent that as yet we can only guess at.





Reproduced by permission of the American Museum of Natural History. THE ACTUAL SKELETON OF *BRONTOSAURUS*

VI

THE AGE OF REPTILES

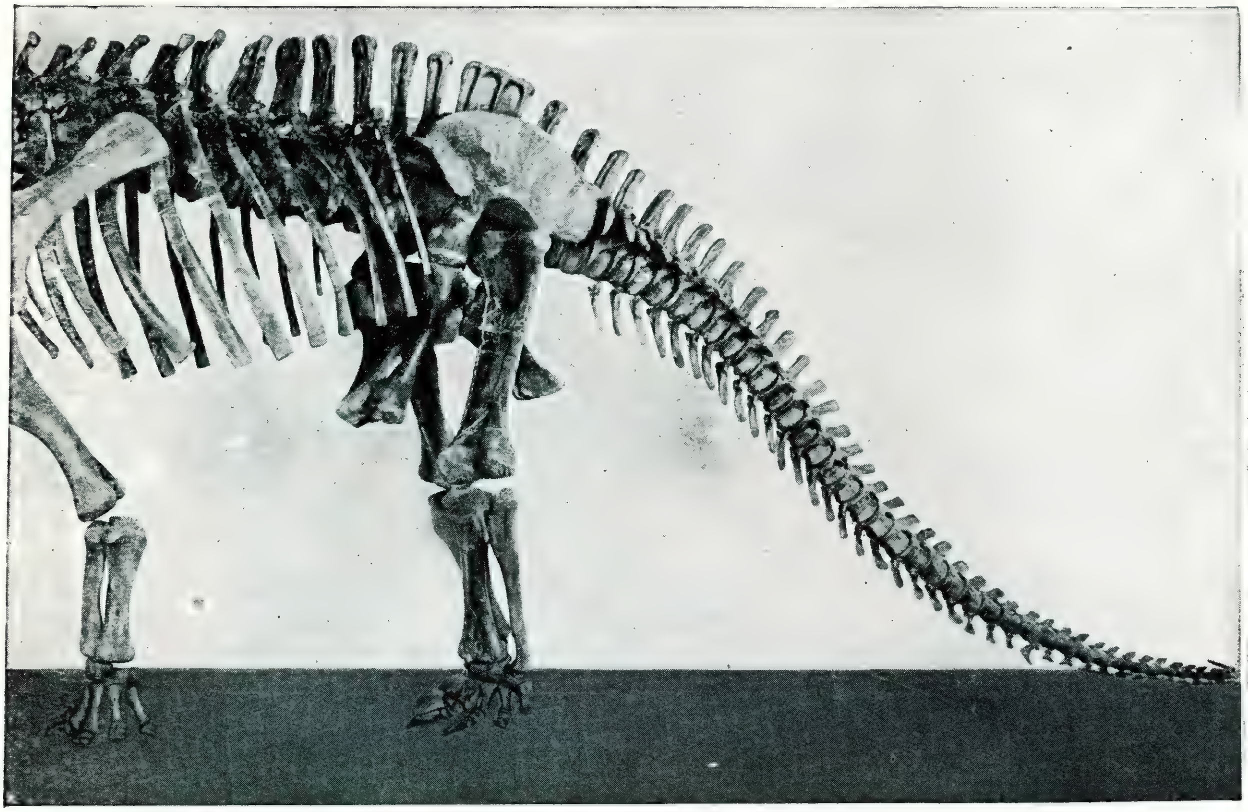
§ 1

The Age of Lowland Life.

WE know that for hundreds of thousands of years the wetness and warmth, the shallow lagoon conditions that made possible the vast accumulations of vegetable matter which, compressed and mummified,[1] are now coal, prevailed over most of the world. There were some cold intervals, it is true; but they did not last long enough to destroy the growths. Then that long age of luxuriant low-grade vegetation drew to its end, and for a time life on the earth seems to have undergone a period of world-wide bleakness.

When the story resumes again, we find life entering upon a fresh phase of richness and expansion. Vegetation has made great advances in the art of living out of water. While the Palæozoic plants of the coal measures probably grew with swamp water flowing over their roots, the Mesozoic flora from its very outset included palm-like cycads and low-ground conifers that were distinctly land plants growing on soil above the water level. The lower levels of the Mesozoic land were no doubt covered by great fern brakes and shrubby bush and a kind of jungle growth of trees. But there were as yet no grass, no small flowering plants, no turf nor greensward. Probably the Mesozoic was not an age of very brightly coloured vegetation. It must have had a flora green in the wet season and brown and purple in the dry. There were no gay flowers,

[1] Dr. Mary Stopes, *Monograph on the Constitution of Coal.*



COMPARED WITH A HUMAN SKELETON.

no bright autumn tints before the fall of the leaf, because there was as yet no fall of the leaf. And beyond the lower levels the world was still barren, still unclothed, still exposed without any mitigation to the wear and tear of the wind and rain.

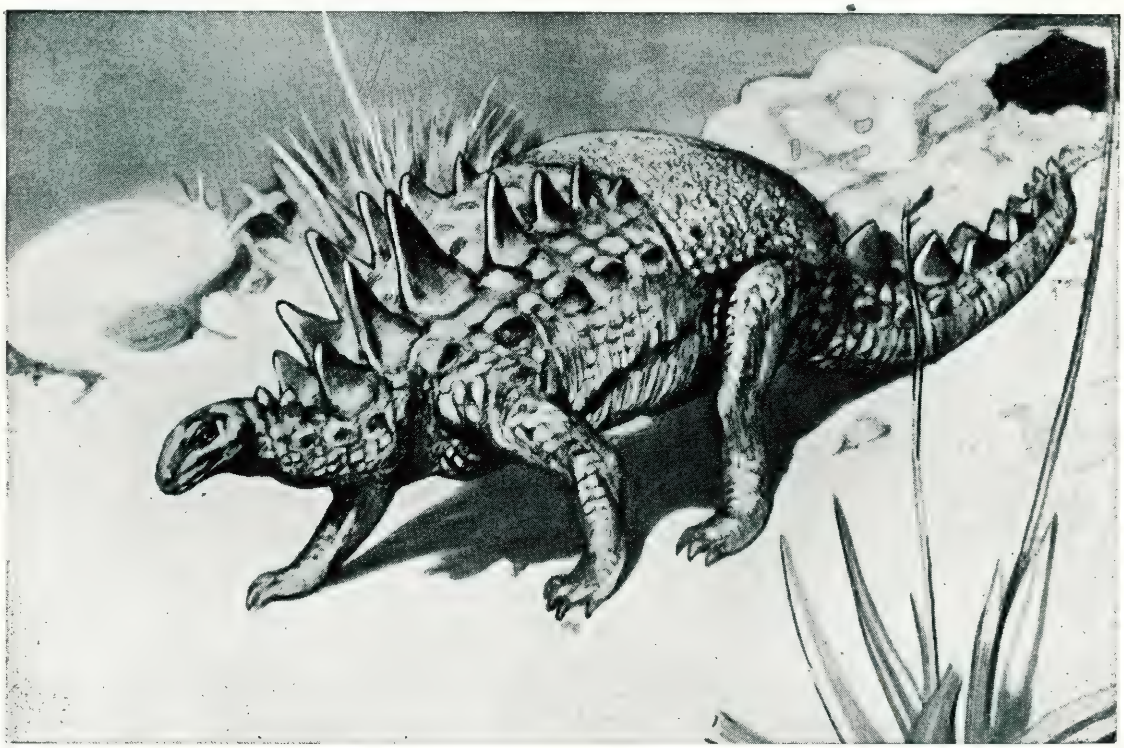
When one speaks of conifers in the Mesozoic, the reader must not think of the pines and firs that clothe the high mountain slopes of our time. He must think of low-growing evergreens. The mountains were still as bare and lifeless as ever. The only colour effects among the mountains were the colour effects of naked rock, such colours as make the landscape of Colorado so marvellous to-day.

Amidst this spreading vegetation of the lower plains the reptiles were increasing mightily in multitude and variety. They were now in many cases absolutely land animals. There are numerous anatomical points of distinction between a reptile and an amphibian; they held good between such reptiles and amphibians as prevailed in the carboniferous time of the Upper Palæozoic; but the fundamental difference between reptiles and amphibia which matters in this history is that the amphibian must go back to the water to lay its eggs, and that in the early stages of its life it must live in and under water. The reptile, on the other hand, has cut out all the tadpole stages from its life cycle, or, to be more exact, its tadpole stages are got through before the young leave the egg case. The reptile has come out of the water altogether. Some had gone back to it again, just as the hippopotamus and the otter among mammals have gone back, but that is a further extension of the story to which we cannot give much attention in this *Outline*.

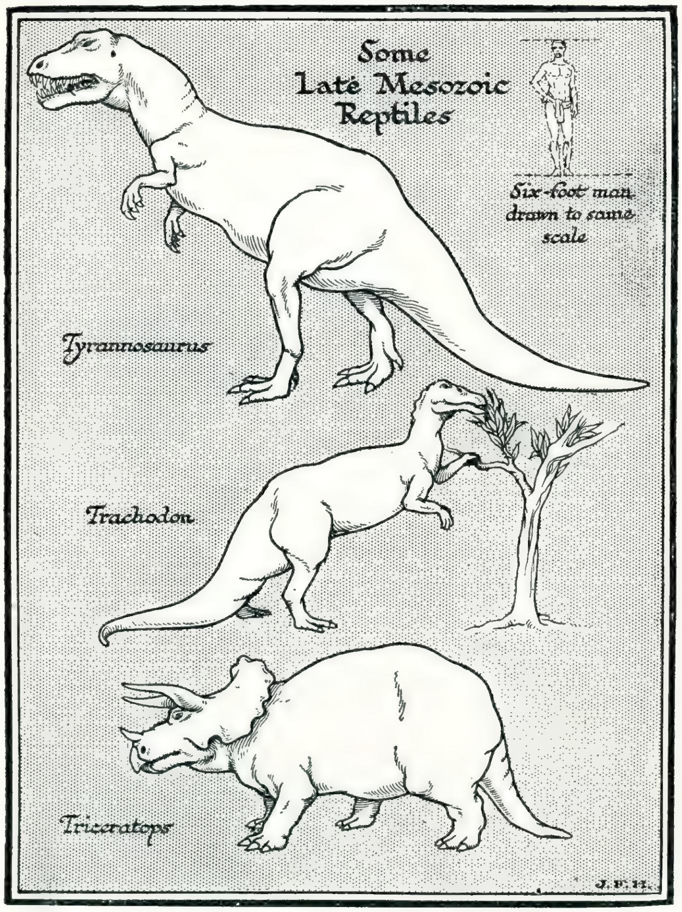
In the Palæozoic period, as we have said, life had not spread beyond the swampy river valleys and the borders of sea lagoons and the like; but in the Mesozoic, life was growing ever more accustomed to the thinner medium of the air, was sweeping boldly up over the plains and towards the hill-sides. It is well for the student of human history and the human future

to note that. If a disembodied intelligence with no knowledge of the future had come to earth and studied life during the early Palæozoic age, he might very reasonably have concluded that life was absolutely confined to the water, and that it could never spread over the land. It found a way. In the Later Palæozoic Period that visitant might have been equally sure that life could not go beyond the edge of a swamp. The Mesozoic Period would still have found him setting bounds to life far more limited than the bounds that are set to-day. And so to-day, though we mark how life and man are still limited to five miles of air and a depth of perhaps a mile or so of sea, we must not conclude from that present limitation that life, through man, may not presently spread out and up and down to a range of living as yet inconceivable.

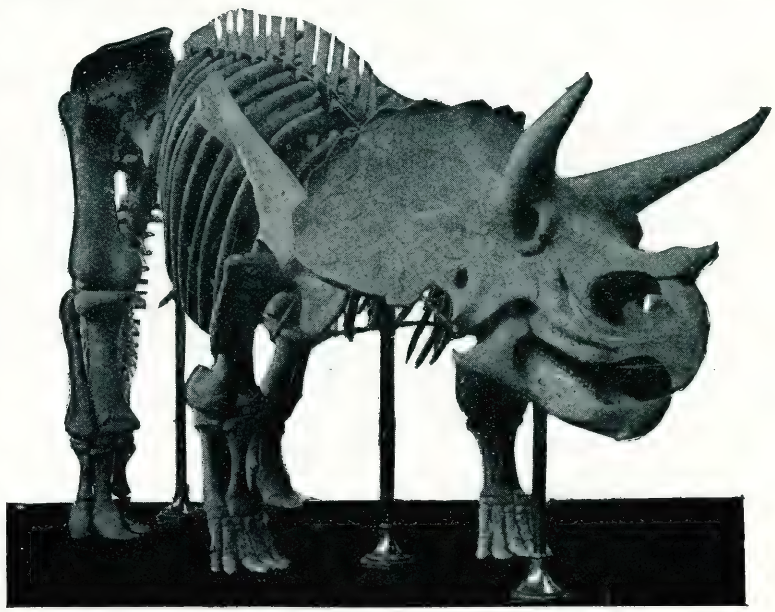
The earliest known reptiles were beasts with great bellies and not very powerful legs, very like their kindred amphibia, wallowing as the crocodile wallows to this day; but in the Mesozoic they soon began to stand up and go stoutly on all fours, and several great sections of them began to balance themselves on tail and hindlegs, rather as the kangaroos do now, in order to release the fore limbs for grasping food. The bones of one notable division of reptiles which retained a quadrupedal habit, a division of which many remains have been found in South African and Russian Early Mesozoic deposits, display a number of characters which approach those of the mammalian skeleton, and because of this resemblance to the mammals (beasts) this division is called the *Theriomorpha* (beastlike). Another division was the crocodile branch, and another developed towards the tortoises and turtles. The *Plesiosaurs* and *Ichthyosaurs* were two groups which have left no living representatives; they were huge reptiles returning to a whale-like life in the sea. *Pliosaurus*, one of the largest plesiosaurs, measured thirty feet from snout to tail tip—of which half was neck. The *Mosasaurs* were a third group of great porpoise-like marine lizards. But the largest and most diversified group of these Mesozoic reptiles was the group we have spoken of as kangaroo like, the *Dinosaurs*, many of which attained enormous



ANOTHER RESTORATION OF A STEGOSAUR.



proportions. In bigness these greater *Dinosaurs* have never been exceeded, although the sea can still show in the whales creatures as great. Some of these, and the largest among them, were herbivorous animals; they browsed on the rushy vegetation and among the ferns and bushes, or they stood up and grasped trees with their fore-legs while they devoured the foliage. Among the browsers, for example, were the *Diplodocus carnegii*, which measured eighty-four feet in length, and the *Atlantosaurus*. The *Gigantosaurus*, disinterred by a German expedition in 1912 from rocks in East Africa, was still more colossal. It measured well over a hundred feet! These greater monsters had legs, and they are usually figured as standing up on them; but it is very doubtful if they could have supported their weight in this way, out of water. Buoyed up by water or mud, they may have got along. Another noteworthy type we have figured is the *Triceratops*. There were also a number of great flesh-eaters who preyed upon these herbivores. Of these, *Tyrannosaurus* seems almost the last word in "frightfulness" among living things. Some species of this genus measured forty feet from snout to tail. Apparently it carried this vast body kangaroo fashion on its tail and hindlegs. Probably it reared itself up. Some authorities even suppose that it leapt through the air. If so, it possessed muscles of a quite miraculous quality. A leaping elephant would be a far less astounding idea. Much more probably it waded half submerged in pursuit of the herbivorous river saurians.



Natural History Museum Photograph.

THE ACTUAL SKELETON OF *TRICERATOPS* UPON WHICH THE FIGURE IN THE PRECEDING ILLUSTRATION IS BASED.

§ 2

Flying Dragons.

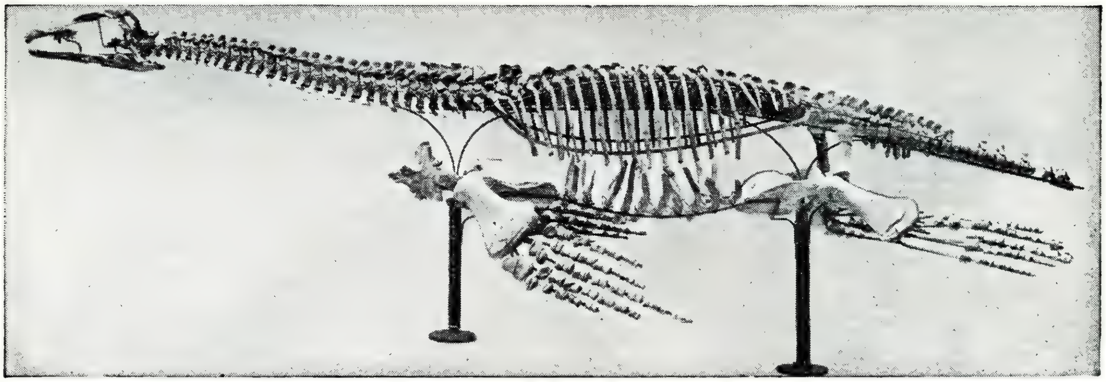
One special development of the dinosaurian type of reptile was a light hopping, climbing group of creatures which developed a bat-like web between the fifth finger and the side of the body, which was used in gliding from tree to tree after the fashion of the flying squirrels. These bat-lizards were the *Pterodactyls.* They are often described as *flying* reptiles, and pictures are drawn of Mesozoic scenery in which they are seen soaring and swooping about. But their breastbone has no keel such as the breastbone of a bird has for the attachment of muscles strong enough for flying. At the most they fluttered. They must have had a grotesque resemblance to heraldic dragons, and they played the part of bat-like birds in the Mesozoic jungles. But bird-like though they were, they were not birds nor the ancestors of birds. The structure of their wings was altogether different from that of birds. The structure of their wings was that of a hand with one long finger and a web; the wing of a bird is like an arm with feathers projecting from its hind edge. And these Pterodactyls had no feathers.

§ 3

The First Birds.

Far less prevalent at this time were certain other truly bird-like creatures, of which the earlier sorts also hopped and clambered and the later sorts skimmed and flew. These were at first—by all the standards of classification—Reptiles. They developed into true birds as they developed wings and as their reptilian scales became long and complicated, fronds rather than scales, and so at last, by much spreading and splitting, feathers. Feathers are the distinctive covering of birds, and they give a power of resisting heat and cold far greater than that of any other integumentary covering except perhaps the thickest fur. At a very early stage this novel covering of feathers, this new heat-proof contrivance that life had chanced upon, enabled many species of birds

ANOTHER RESTORATION OF *TRICERATOPS.*



Natural History Museum Photograph.

THE ACTUAL SKELETON OF A PLESIOSAUR UPON WHICH THE LARGE COLOURED ILLUSTRATION IS BASED.

to invade a province for which the pterodactyl was ill equipped. They took to sea fishing—if indeed they did not begin with it—and spread to the north and south polewards beyond the temperature limits set to the true reptiles. The earliest birds seem to have been carnivorous divers and water birds. To this day some of the most primitive bird forms are found among the sea birds of the Arctic and Antarctic seas, and it is among these sea birds that zoologists still find lingering traces of teeth, which have otherwise vanished completely from the beak of the bird.

The earliest known bird (the *Archæopteryx*) had no beak; it had a row of teeth in a jaw like a reptile's. It had three claws at the forward corner of its wing. Its tail too was peculiar. All modern birds have their tail feathers set in a short compact bony rump; the *Archæopteryx* had a long bony tail with a row of feathers along each side.

§ 4

An Age of Hardship and Death.

This great period of Mesozoic life, this second volume of the book of life, is indeed an amazing story of reptilian life proliferating and developing. But the most striking thing of all the story remains to be told. Right up to the latest Mesozoic Rocks we find all these reptilian orders we have enumerated still flourishing unchallenged. There is no hint of an enemy or competitor to them in the relics we find of their world. Then the record is broken. We do not know how long a time the break represents; many pages may be missing here, pages that may represent some great cataclysmal climatic change. When next we find abundant traces of the land plants and the land animals of the earth, this great multitude of reptile species had gone. For the most part they have left no descendants. They have been "wiped out." The pterodactyls have gone absolutely, of the plesiosaurs and ichthyosaurs none are alive; the mosasaurs have gone; of the lizards a few small forms remain, the iguana is the largest; all the multitude and diversity of the dinosaurs have vanished. Only the crocodiles and the turtles and tortoises carry on in any quantity into Cainozoic times. The place of all these types in the picture that the Cainozoic fossils presently unfold to us is taken by other animals not closely related to the Mesozoic reptiles and certainly not descended from any of their ruling types. A new kind of life is in possession of the world.

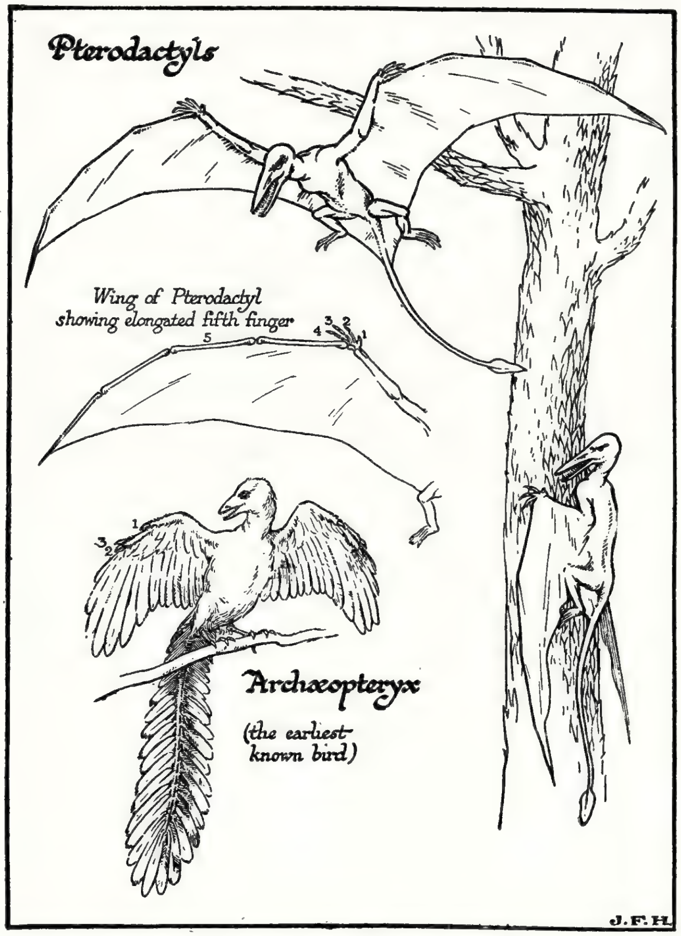
This apparently abrupt ending up of the reptiles is, beyond all question, the most striking revolution in the whole history of the earth before the coming of mankind. It is probably connected with the close of a vast period of equable warm conditions and the onset of a new austerer age, in which the winters were bitterer and the summers brief but hot. The Mesozoic life, animal and vegetable alike, was adapted to warm conditions and capable of little resistance to cold. The new life, on the other hand, was before all things capable of resisting great changes of temperature.

Whatever it was that led to the extinction of the Mesozoic reptiles, it was probably some very far-reaching change indeed, for the life

of the seas did at the same time undergo a similar catastrophic alteration. The crescendo and ending of the Reptiles on land was paralleled by the crescendo and ending of the Ammonites, a division of creatures like squids with coiled shells which swarmed in those ancient seas. All through the rocky record of this Mesozoic period there is a vast multitude and variety of these coiled shells; there are hundreds of species, and towards the end of the Mesozoic period they increased in diversity and produced exaggerated types. When the record resumes these too have gone. So far as the reptiles are concerned, people may perhaps be inclined to argue that they were exterminated because the Mammals that replaced them, competed with them, and were more fitted to survive; but nothing of the sort can be true of the Ammonites, because to this day their place has not been taken. Simply they are gone. Unknown conditions made it possible for them to live in the Mesozoic seas, and then some unknown change made life impossible for them. Only one genus of Ammonite survives to-day of all that vast variety, the Pearly Nautilus. It is found, it is to be noted, in the warm waters of the Indian and Pacific Oceans.[1]

And as for the Mammals competing with and ousting the less fit reptiles, a struggle of which people talk at times, there is not a scrap of evidence of any such direct competition. To judge by the Record of the Rocks as we know it to-day, there is much more reason for believing that first the reptiles in some inexplicable way perished, and then that later on, after a very hard time for all life upon the earth, the mammals, as conditions became more genial again, developed and spread to fill the vacant world.

[1] See article "Cephalopoda" in the *Encyclopædia Britannica* for its anatomy.



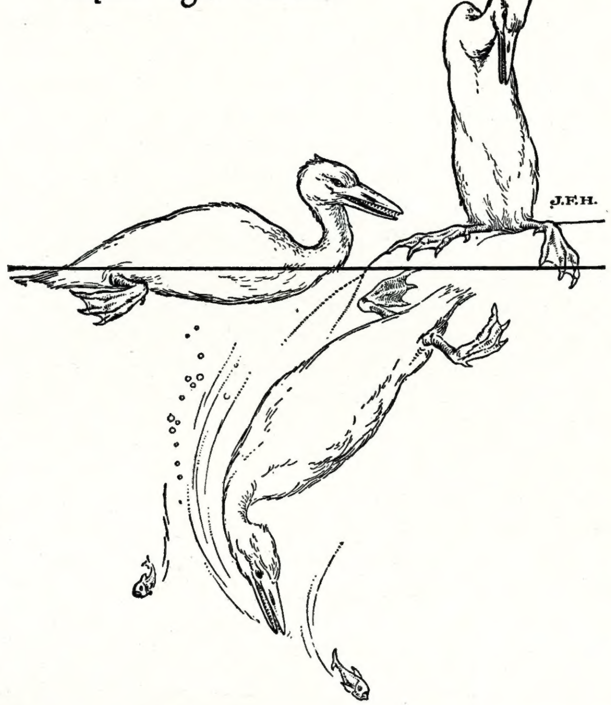
RESTORATION OF PTERODACTYLS AND EARLY BIRDS BASED ON SUCH FOSSIL REMAINS AS WE HAVE SHOWN IN OUR FIRST ILLUSTRATION.

§ 5

Were there mammals in the Mesozoic period ?

This is a question not yet to be answered precisely. Patiently and steadily the geologists gather fresh evidence and reason out completer conclusions. At any time some new deposit may reveal fossils that will illuminate this question. Certainly either mammals, or the ancestors of the mammals, must have lived throughout the Mesozoic period. In the very opening chapter of the Mesozoic volume of the Record there were those Theriomorphous Reptiles to which we have already alluded, and in the later Mesozoic a number of small jaw-bones are found, entirely mammalian in character. But there is not a scrap, not a bone, to suggest that there lived any Mesozoic Mammal which could look a dinosaur in the face. The Mesozoic mammals or mammal-like reptiles, for we do not know clearly which they were, seem to have been all obscure little beasts of the size of mice and rats, more like a down-trodden order of reptiles than a distinct class; probably they still laid eggs and were developing only slowly their distinctive covering of hair. They lived away from big waters, and perhaps in the desolate uplands, as marmots do now; probably they lived there beyond the pursuit of the carnivorous dinosaurs. Some perhaps went on all fours, some chiefly went on their hind-legs and clambered with their fore limbs. They became fossils only so occasionally that chance has not yet revealed a single complete skeleton in the whole vast record of the Mesozoic rocks by which to check these guesses.

The First Appearance of Fur and Feathers.



Hesperornis
(Reptilian wingless water-bird)

These little Theriomorphs, these ancestral mammals, developed hair. Hairs, like feathers, are long and elaborately specialized scales. Hair is perhaps the clue to the salvation of the early mammals. Living lives upon the margin of existence, away from the marshes and the warmth, they developed an outer covering only second in its warmth-holding (or heat-resisting) powers to the down and feathers of the Arctic sea-birds. And so they held out through the age of hardship between the Mesozoic and Cainozoic ages, to which most of the true reptiles succumbed.

All the main characteristics of this flora and sea and land fauna that came to an end with the end of the Mesozoic age were such as were adapted to an equable climate and to shallow and swampy regions. But in the case of their Cainozoic successors, both hair and feathers gave *a power of resistance to variable temperatures* such as no reptile possessed, and with it they gave a range far greater than any animal had hitherto attained.

The range of life of the Lower Palæozoic Period was confined to warm water.

The range of life of the Upper Palæozoic Period was confined to warm water or to warm swamps and wet ground.

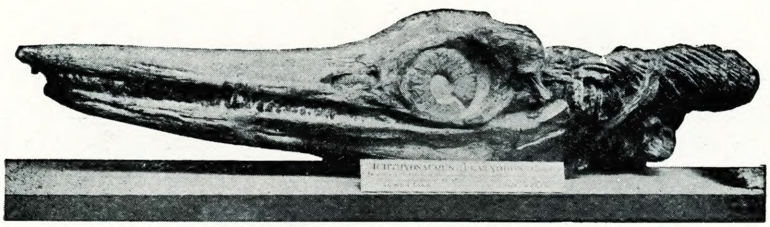
The range of life of the Mesozoic Period as we know it was confined to water and fairly low-lying valley regions under equable conditions.

Meanwhile in each of these periods there were types involuntarily extending the range of life beyond the limits prevailing in that period; and when ages of extreme conditions prevailed, it was these marginal types which survived to inherit the depopulated world.

That perhaps is the most general statement we can make about the story of the geological record; it is a story of widening range. Classes, genera, and species of animals appear and disappear, but the range widens. It widens always. Life has never had so great a range as it has to-day. Life to-day, in the form of man, goes higher in the air than any other creature has ever done, his geographical range is from pole to pole, he goes under the water in submarines, he sounds the cold, lifeless darkness of the deepest seas, he burrows into virgin levels of the rocks, and in thought and knowledge he pierces to the centre of the earth and reaches out to the uttermost star. Yet in all the relics of the Mesozoic time we find no certain memorials of his ancestry. His ancestors, like the ancestors of all the kindred mammals, must have been creatures so rare, so obscure, and so remote that they have left scarcely a trace amidst the abundant vestiges of the monsters that wallowed rejoicing in the steamy air and lush vegetation of the Mesozoic lagoons, or crawled or hopped or fluttered over the great river plains of that time.[1]

[1] And here the genius of a great humorous artist (E. T. Reed) obliges us to add a footnote to clear away a common misconception. He was the creator of a series of fantastic pictures, *Prehistoric Peeps*, which have had a deserved and immense vogue, and it was his whim to represent primitive men as engaged in an unending wild struggle with great Plesiosaurs and the like. His fantasy has become a common belief. As a matter of fact, millions of years elapsed between the vanishing of the last great Mesozoic reptile and the first appearance of man upon this earth. Early man had as contemporaries some monstrous animals, as we shall note, but not these extreme monsters.

In these six opening chapters we have been much indebted, in addition to the books already named in the text or in footnotes, to Ray Lankester's *Extinct Animals*, Osborn's *Age of Mammals*, Jukes Browne's, Lyell's and Pirsson and Schuchert's text-books of geology, and the collections and catalogues of the Natural History Museum at South Kensington. H. R. Knipe's admirably illustrated *From Nebula to Man* and his *Evolution in the Past* have also been very useful and suggestive.



Natural History Museum Photograph.

AN EXTINCT LORD OF CREATION.

Head of a Mesozoic *Ichthyosaur*. Note the extraordinary circle of bone round the eye.

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